

LUNDQUA



THESIS

THE DEGLACIATION OF THE EASTERN
PART OF SKÅNE, SOUTHERN SWEDEN.

A STUDY OF TILL AND STRATIFIED DRIFT

Åmark, Max

Lund 1984

Volume 15

Lund University, Departement of Quaternary Geology



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A contribution to IGCP project 24
(Quaternary Glaciations in the Northern Hemisphere)

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Title and subtitle The deglaciation of the eastern part of Skåne, southern Sweden. A study of till and stratified drift.				
Abstract The course of deglaciation was determined chiefly by studying the genesis of the stratified drift, but also by genetical and lithological investigations of till. The ice sheet receded in a northeasterly direction in the southern part of the investigated area and in a northerly direction in the northern part. The ice sheet receded gradually and was active except for a zone of stagnant ice that remained in areas where the deglaciation was subaerial. At least in a marginal zone, the ice sheet was mainly at the pressure melting point. Here, surface meltwater penetrated the ice sheet and flowed along its base. The till was mainly deposited at the base of the ice sheet. To some extent, it is made up of stratified drift that was deformed by active ice. The glaciofluvial sediments were transported by subglacial meltwater. The meltwater drainage was controlled by valleys and depressions. Where the deglaciation was subaerial, the sediments accumulated in the zone with stagnant ice. Where the ice sheet terminated in standing water, deposition took place at the ice margin.				
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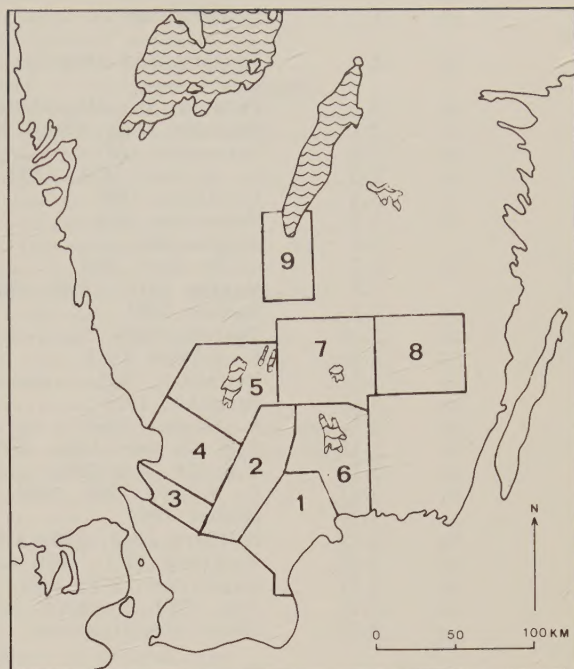
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Foreword

The deglaciation of southern Sweden is a classical field of research. Several deglaciation models have been presented, often with contradictory and controversial results. These older models are mainly based upon the regional morphology, topography and geological maps combined with often questionable chronological data but not on the lithostratigraphy. The different views have been reviewed by Berglund (1976, 1979). At the Department of Quaternary Geology at the Lund University a project was organized with one group treating the biostratigraphy and deglaciation chronology and an other group the lithostratigraphy and deglaciation pattern and dynamics (Berglund 1976). The project is included in the Swedish program of IGC-project 24 "Quaternary Glaciations in the Northern Hemisphere" (QG).

The lithostratigraphical subproject was organized by Gert Knutsson and Erik Lagerlund. Nine graduate students were assigned a field study area for which the process of deglaciation was to be determined. These are shown in the map. Lagerlund has been the main supervisor for the graduate students and from 1980 alone the leader of the subproject. Within the group several methodological seminars and excursions were organized and different experts have visited the field study areas (e.g. G.S. Boulton, A. Dreimanis, J. Shaw, C.-E. Johansson). Excursions with other Swedish QG-groups as well as the QG-symposium in Stockholm 1981 have also been of great importance for the progress of our work. As a Swedish QG-subproject our group has received economic support from the Swedish Natural Science Research Council.

The author of the present thesis, Max Åmark, was studying the Kristianstad area in eastern Skåne, southern Sweden (number 1 on the map). Results from the other field study areas will be published in the near future in the LUNDQUA Thesis series. A preliminary synthesis of our subproject is published in the LUNDQUA Report series, vol. 24 (Lagerlund et al. 1983). In that report a new model



The field study areas: 1) the Kristianstad area, author, 2) the Hässleholm area, Mats Hebrand, 3) the Ängelholm area, Per Sandgren (LUNDQUA thesis 14), 4) the Laholm area, Joanne Mae Robison (LUNDQUA Thesis 13), 5) the Bolmen area, Bengt Karlgren, 6) the Åsnen area, Per Möller, 7) the Växjö area, Lars-Olof Jönsson, 8) the Åseda area, Thomas Terne, 9) the Jönköping area, Dan Waldemarsson.

of the deglaciation pattern in southern Sweden, based exclusively on lithostratigraphical and glacial geological evidence, is presented.

Lund, April 1984

Erik Lagerlund



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Plate 1 - 6

1 Introduction

The investigated area comprises the eastern part of the province of Skåne, which in this work is named the Kristianstad area (Fig. 1). The purpose of the investigation was to study the Late Weichselian deglaciation in the Kristianstad area and to discuss it in Hanöbukten Bay east of this area. The investigation is part of a project dealing with the deglaciation in southern Sweden, which in turn is a subproject of the IGCP Project 24, Quaternary Glaciations in the Northern Hemisphere.

My studies are based mainly on investigations of the glaciofluvial deposits, since other kinds of glacial deposits that were formed with certainty during the deglaciation are few.

The occurrence of ice disintegration features in till and stratified drift in southern Sweden has often been considered to indicate that the ice sheet here had a very gently sloping surface during the deglaciation, was stagnant and melted off more or less simultaneously from large areas. The opinion that the ice sheet had a more steeply sloping surface during the deglaciation, was active, and melted off gradually has also been put forward. Therefore, the intention of the present investigation was among other things to understand how the ice sheet melted off in the Kristianstad area. My hypothesis was that if the glaciofluvial deposits accumulated more or less simultaneously, this would indicate that the ice sheet had a very gently sloping surface and was stagnant during the deglaciation. On the other hand, if the accumulation was gradual, this would point to the gradual recession of a probably active ice sheet with a 'considerable' surface slope. It was also considered that the glaciofluvial deposits might yield information about the direction of slope of the ice surface. If the recession was gradual, it would then be possible to obtain the trend of the ice margin or the trend of the boundary between active and stagnant glacier ice.

In previous investigations the opinion was expressed that a great number of the glacial striae found on exposed bedrock surfaces in the Kristianstad area reflect ice movement directions prior to the deglaciation. It was, therefore, in my opinion important to determine when the glacial striae had been formed. If the ice sheet was stagnant during the deglaciation, the striae ought to reflect earlier ice movements. On the other hand, if the ice sheet was active during the deglaciation, the majority of the striae ought to have formed during this period and, consequently, would give information on the trend of the ice margin or the trend of the boundary between active and stagnant glacier ice.

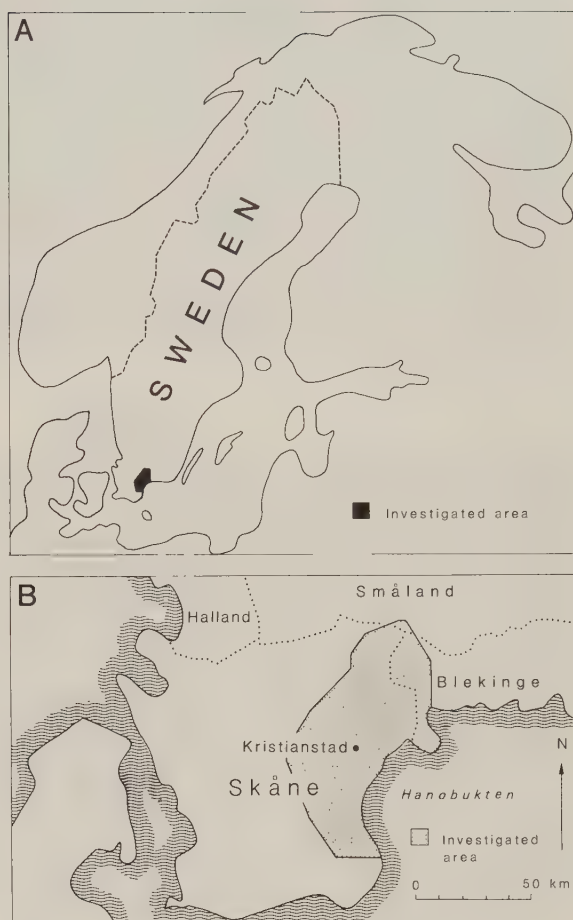


Fig. 1. Location of the investigated area. A. Fenno-Scandinavia. B. The province of Skåne and the surrounding provinces.

It has previously been assumed that the ice sheet was temperate during the deglaciation. This assumption is not necessarily correct and, therefore, I have discussed the temperature of the ice sheet mainly on the basis of the glaciofluvial deposits.

Several different ice movement directions are considered to have occurred in Skåne during the Weichselian glaciation. Two of these directions are of importance to the deglaciation and I have studied them by means of genetic investigations of till and by lithological analyses in till and stratified drift.

2 Investigated area

The central part of the investigated area consists of a low-lying plain (Fig. 2, Plate 1). In general, it reaches less than 30 m a.s.l. and has a level or gently undulating surface (Fig. 3A). The plain is bounded in the south by the Linderödsåsen horst and in the west by the Nävlingeåsen horst. The north-eastern sides of the horsts are steep, 75-100 m high and incised by up to 75 m deep valleys (Fig. 3B). The top surfaces of the horsts are situated mainly between 100 m and 200 m a.s.l. and are gently undulating (Fig. 3C). The valleys and depressions occurring

here are less than 25 m deep. North of Kristianstad, the plain is replaced by a valley landscape. The valleys are mainly less than 25 m deep except for in the area north-east of Kristianstad where they are up to 100 m deep (Fig. 3D).

The plain around Kristianstad is underlain by Cretaceous limy sandstone, sandy limestone and limestone while Archean gneiss and granite mainly make up the bedrock in the rest of the area (Fig. 57). The bedrock exposures are small, occur sparsely and are most frequent in the area northeast of Kristianstad.

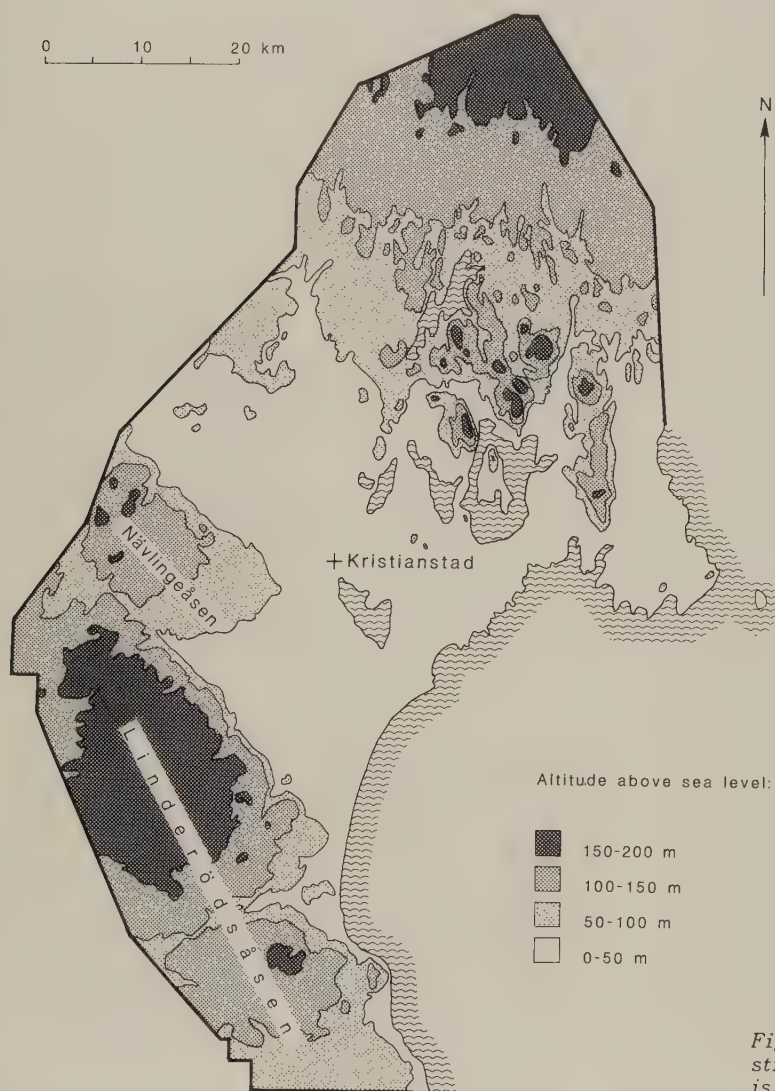


Fig. 2. The morphology of the Kristianstad area. The contour interval is 50 m.

Fig. 3. Landscape types in the Kristianstad area. A. A view of the plain around Kristianstad, northeast of N. Åsum (Plate 1). The Nävlingeåsen horst is seen in the background. The photo is taken 1 km north of N. Åsum toward the west. B. The northern side of the valley in which Brösarp is situated (Plate 1: area 7). The photo is taken 1 km north of Brösarp toward the west-southwest. C. A gently undulating landscape on the Linderödsåsen horst east of S:t Olof (Plate 1: area 8). The photo is taken 1 km east of S:t Olof toward the northeast. D. A view of the valley landscape north of Kristianstad. The photo shows the eastern side of the hill of Oppmannaberget (Plate 1). The photo is taken toward the north-northwest from the northern part of the island of Ivön.

A



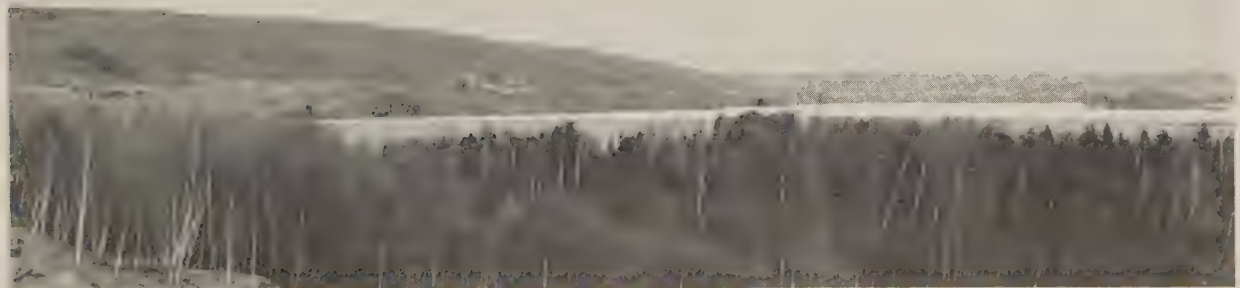
B



C



D



The glacial striae indicate an ice movement from the northeast in the southern part of the area and from between the north and the northeast in the northern part.

For the most part, the till forms a cover that reflects the irregularities of the underlying bedrock. Drumlin-shaped hills occur around Ivösjön Lake and on the peninsula of Listerlandet. They are up to at least 9 km long and as much as 1.5 km wide and 100 m high. Hummocks of till, about 100 m in diameter and 5 m high are found on the horsts and in the valley landscape north of Kristianstad. Usually the till rests directly on the bedrock, but till underlain by stratified drift and double till beds with intervening stratified drift are found on the plain around Kristianstad and along the eastern border of the Linderödsåsen horst. The till is mainly sandy, but clayey till and clay till also occur.

The glaciofluvial deposits on the Linderödsåsen horst consist of stony gravelly sand and sand. Ridges and extended hummocky deposits make up the morphological elements of the stony gravelly sand which occurs in mainly northeast-southwest trending zones. The sand which is found on the eastern part of the horst forms extended accumulations with level or hummocky surfaces and are often dissected by brooks.

The glaciofluvial deposits on the plain around Kristianstad are largely made up of

gravelly sand and sand. They form zones trending between the north-south and the northeast-southwest. In the areas north and southwest of Kristianstad, the gravelly sand forms mounds and plateaus that are surrounded and partly covered by sand. Ridges of stony gravelly sand also occur here. On the rest of the plain, the glaciofluvial deposits are often covered by varved clay and beach sand.

The glaciofluvial deposits in the valley landscape north of Kristianstad consist for the most part of gravelly sand and sand below 50-60 m a.s.l. Above this level, they are made up of stony gravelly sand. The gravelly sand forms mounds and plateaus and the stony gravelly sand forms ridges, mounds and hummocks. The stratified drift occurs in zones trending between the north-northwest - south-southeast and the north east-southwest.

Varved clay is found all over the plain around Kristianstad below about 25 m a.s.l. Except for in the area around and northwest of Kristianstad, it is often covered by beach sand. In the southern part of the valley landscape, the varved clay reaches up to about 40 m a.s.l. and is also here often overlaid by beach sand.

Beach deposits are found up to 50-60 m a.s.l. in the area north of Kristianstad and up to 25-40 m a.s.l. along the eastern slope of the Linderödsåsen horst.

3 Previous investigations

This chapter deals with investigations concerning the glaciation and the deglaciation of the eastern part of Skåne and the genesis of the glacial deposits occurring here. Geological maps and other kinds of geological information describing the glacial deposits in the Kristianstad area are dealt with in Chapter 4.1.

More than anything else, the ice movement directions during the Weichselian glaciation, the recession of the Weichselian ice sheet and the occurrence of glacial lakes during the deglaciation period have been discussed in the literature concerned with the glacial history of the Kristianstad area. Although the aim of this work was to shed light on the deglaciation, it is necessary in this chapter to touch upon all the aspects of the glaciation, since the opinions about the course of the deglaciation were often based on what had happened earlier during the glaciation.

The investigations are presented in chronological order. The opinions on the trend of the ice margin are shown in Plate 2.

The following concepts and terminology are used in this chapter. The term 'ice stream' (in Swedish: 'isström') frequently occurs in literature dealing with the glaciation and the deglaciation in Sweden. It denotes a specific direction of movement in an ice sheet or a lobe projecting from the ice sheet. A 'northerly ice stream' is an ice stream with a direction of movement from the north toward the south. 'Southeasterly glacial striae' are striae which were formed by an ice sheet with a direction of movement from the southeast toward the northwest. The provenance of a 'Baltic indicator' is usually in the area between the islands of Öland and Åland (Plate 2A). The word 'Scandinavia' denotes Denmark, Norway and Sweden (Plate 2A). 'Fenno-Scandinavia' is used if Finland also is included.

3.1 Sefström 1836. Torell 1859, 1865. Holmström 1865.

Sefström (1836) was the first to describe striated and polished bedrock surfaces in Sweden. His investigation covers the southern part of Sweden. One site with striae was observed in the eastern part of Skåne at Simrishamn. The location of Simrishamn is shown in Plate 2B. Sefström was of the opinion that the striae were formed by running water carrying cobbles and pebbles.

Torell (1859) concluded that the striae described by Sefström were formed by an ice sheet that covered Fenno-Scandinavia. In a preface in Holmström (1865), Torell claimed that not only Fenno-Scandinavia but all of Northern Europe was covered by an ice sheet with its outermost limit indicated by the dispersal of indicators.

Torell (1865) divided the glaciation into five phases. During the third phase, the direction of movement of the ice sheet in the southern part of the glaciated area was controlled by the Baltic depression. This depression resulted in a 'Baltic ice stream' here (Fig. 4A). The existence of this ice stream was deduced from the glacial striae on the islands in the Baltic, in the eastern part of Skåne at Simrishamn (Sefström 1836) and from the occurrence of Baltic indicators in the

Netherlands. According to Torell (1865), this ice stream covered the southern part of Skåne. In the rest of southern Sweden, a northerly to northeasterly ice stream prevailed simultaneously. The new observations of glacial striae made by Holmström (1865), mainly in the provinces of Skåne and Blekinge, supported this opinion.

3.2 Holmström 1867

Holmström (1867) presented new observations on glacial striae and developed Torell's (1859, 1865) theory on the ice streams in the south of Sweden.

The extension and direction of movement of Torell's Baltic ice stream was determined in further detail in Skåne by the findings of east-northeasterly glacial striae in the southern part of the province (Plate 2B). The northernmost extension of this ice stream is marked by line 1 in Plate 2B. The north-easterly glacial striae occurring north of line 1 were considered to have resulted when the Baltic ice stream forced a simultaneously-occurring northerly ice stream in southern Sweden to deviate toward the southwest in Skåne.

A northerly ice stream prevailed in most of Skåne when the influence from the Baltic ice stream decreased here. Holmström thought that the central and southwestern parts of the province became deglaciated during this period. The existence and extension of the northerly ice stream were based on the northerly striae at Simrishamn, in the northern part of Skåne and in the southwestern part of the province of Blekinge. According to Torell (1865), the striae in the latter two areas were younger than the easterly striae in the southern part of Skåne and were eroded by a northerly ice stream.

The easternmost part of Skåne was again influenced by a Baltic ice stream (Plate 1B: line 2). Holmström concluded this from the northeasterly striae found west of Simrishamn. He had observed that these were younger than the northerly striae here. The Baltic ice stream influenced Skåne only a short distance west of the coast-line, since the northerly striae west of Simrishamn would otherwise have been eroded away. Holmström believed that this ice stream was also in contact with an ice stream with a direction of movement from the north in the province of Småland. He based this conclusion on the northeasterly glacial striae in the southeasternmost part of Blekinge and the north-northeasterly striae on the peninsula of Listerlandet. According to Holmström, these striae could only be explained by a Baltic ice stream forcing the northerly ice stream to deviate toward the south-southwest.

The northerly striae in Skåne and the north-northwesterly to northerly striae in Blekinge and Småland were formed when the Baltic ice stream no longer had an effect on this area. The ice stream in the south of Sweden was by then so thin that the bedrock topography controlled the direction of movement.

3.3 G. De Geer, 1884, 1889a, 1889b, 1896

G. De Geer (1884) was of the opinion that Fenno-Scandinavia was glaciated twice, with an interglacial separating the two glaciations.

During the first glaciation, the ice sheet covered the whole of Northern Europe. The direction of movement of the ice sheet in Skåne, Småland and Blekinge as well as on the island of Bornholm was by then from between the north-northwest and the northeast, as the dashed flow lines in Plate 2C indicate. He obtained these flow lines from the glacial striae (cf. Plate 1). In contrast to Holmström (1867), De Geer believed that all striae indicating directions of movement from between the north-northwest and the northeast were eroded by the same ice stream. The difference between his glaciation model from 1884 and 1896 is that in 1896 he considered that a Baltic ice stream occurred in Skåne before the ice sheet had a movement from between the north-northwest and the northeast here. The 1896 model was based on investigations made by among others (Lundbohm (1888) and himself (G. De Geer 1889a).

De Geer (1884) believed that the zone of terminal moraines in south-central Sweden and in the southernmost parts of Norway and Finland indicated the outermost extension of the ice sheet during the second glaciation (Fig. 4B). However, the ice sheet formed a lobe or a Baltic ice stream, which occurred in the Baltic depression and also covered the southern part of Skåne (Plate 2C). De Geer considered that this lobe must have existed, since it otherwise was not possible to explain the tills with Baltic indicators in the southern part of Skåne. Erdmann (1874) and Holmström (1874) had found that this till was underlain by till deposited by a northerly or northeasterly ice stream, i.e. during the first glaciation. De Geer (1884) considered that the Baltic ice stream had covered the area in the southern part of Skåne where Baltic indicators had been found. He did not think that Holmström's (1867) northeasterly striae west of Simrishamn were formed by a Baltic ice stream.

The central part of the island of Bornholm, which reaches about 125 m a.s.l., was considered to have protruded above the surface of the Baltic ice stream (Plate 2C). De Geer came to this conclusion, since the glacial striae here are northeasterly. Southeasterly striae occur in the lower-lying, surrounding areas. From the height difference between the central part of Bornholm and the bottom of the Baltic depression, he estimated that the Baltic ice stream was about 150 m thick.

In my investigation area, De Geer based his ice stream model on stratigraphical investigations in the area around Brösarp (Plate 2C). He had found here double till beds interbedded by stratified drift (G. De Geer 1889a). The lower till was sandy and contained fragments of Cretaceous limestone, mica quartzite and some Baltic indicators. The fragments of Cretaceous rocks were considered to have been derived from the area around Kristianstad and the mica quartzite from north-east of Kristianstad (Plate 2C). He concluded, therefore, that the lower till was deposited by an ice stream with a direction of movement from between the north and the north-northeast. He also believed that it was deposited simultaneously with the till in the northeastern part of Skåne. Indicators from Småland (Plate 2C) and fragments of mica quartzite in the till here indicated an ice movement from the north (G. De Geer 1889b). The Baltic indicators in the lower till were

explained to be the remnants of a till that was laid down by an easterly ice stream which covered the area before the ice movement from between the north and the north-northeast prevailed. The extent of the upper till showed that the Baltic ice stream had reached only some kilometers inside the coastline. The stratified drift below the upper till showed that the area was deglaciated before the Baltic ice stream advanced.

The geological mapping (De Geer 1889a, 1889b) showed that beach deposits are common up to 50–60 m a.s.l. in the northeastern part of Skåne and up to 40 m a.s.l. in the area around Brösarp (Plate 2C). South of Brösarp, at Simrishamn, beach deposits reach 20 m a.s.l. (Holst 1892). De Geer and Holst believed that the Baltic depression was a bay of the ocean during the deglaciation. The highest level of the beach deposits represented, therefore, the highest level reached by the ocean in the eastern part of Skåne.

3.4 Lundbohm 1888

Lundbohm (1888) presented observations which indicated that a Baltic ice stream had occurred prior to the northerly to northeasterly ice stream in Skåne (cf. Chapter 3.3, G. De Geer 1884). Some of these observations were made in my investigation area.

Lundbohm had found easterly striae on the hill of Ryssberget, Baltic indicators in beach gravel at Lake Ivösjön and Baltic indicators in till at Brösarp (Plate 2D). The till at Brösarp was investigated by G. De Geer (1889a) and named 'lower till' (Chapter 3.3). The striae and Baltic indicators were observed in an area that had not been covered by the Baltic ice stream (Plate 2D). Lundbohm believed that the till in this area was deposited mainly by a northerly to northeasterly ice stream that was older than the Baltic ice stream (cf. Chapter 3.3). The northeasterly to northerly ice stream was indicated by the northerly to northeasterly glacial striae predominating here (Plate 1) and indicators from Småland. He concluded that the easterly striae and the Baltic indicators originated from a Baltic ice stream that had existed in Skåne prior to the northerly to northeasterly ice stream.

3.5 Holmström 1904

Holmström (1904) reassessed some of his earlier opinions (Holmström 1867) and presented a more complete ice stream model in the light of observations made by himself and other geologists after 1867.

He thought that the oldest ice stream in Skåne was a Baltic ice stream (cf. Lundbohm 1888) and named it the Old Baltic Ice Stream (in Swedish: 'gammalbaltiska isströmmen').

The Old Baltic Ice Stream was followed by a north-northwesterly to northerly ice stream that he called the Meridian Ice Stream (in Swedish: 'Meridianisströmmen'). Holmström considered that this ice stream was indicated by the north-northwesterly and northerly striae in Skåne and Blekinge. In my investigation area, this opinion was based on the following observations of glacial striae. At a number of sites located north of Kristianstad (Plate 2E), G. De Geer (1889b) had found north-northwesterly striae which he considered to be older than the northerly to north-northeasterly striae generally occurring here. West of Rörum

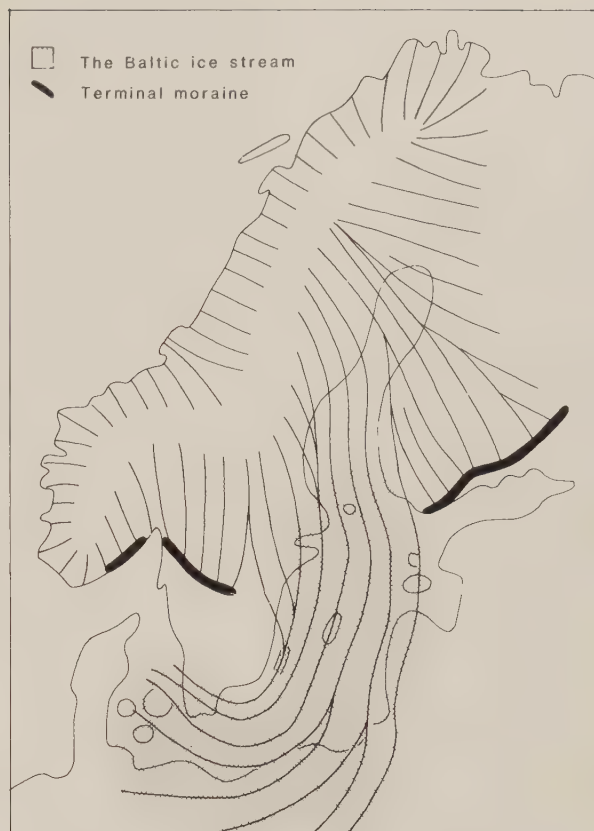
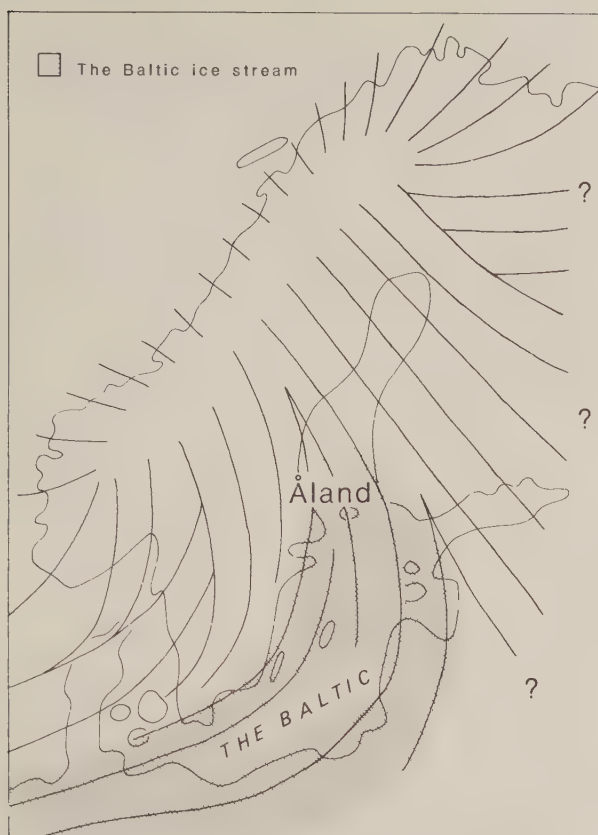


Fig. 4. Baltic ice streams. A. The approximate extent and directions of movement of the ice sheet during the third phase of the glaciation according to Torell (1865). Fig. 4A is mainly based on Lagerlund (1977). B. The extent of the ice sheet during the second glaciation according to G. De Geer (1884). A Baltic ice stream occurred in the Baltic depression. In southern Sweden, only Skåne was covered by the ice sheet.

(Plate 2E), Holmström found northerly striae that were older than the northeasterly striae direction predominating here. He believed that the older striae at the observed sites were eroded by the Meridian Ice Stream.

The third ice stream, the High Baltic Ice Stream (in Swedish: 'högbaltiska isströmmen') had a direction of movement from between the north and the east-northeast in Skåne. In my investigation area, this ice stream was indicated by the younger striae at the sites north of Kristianstad and west of Rörum (Plate 2E). The transition from the Meridian Ice Stream to the High Baltic Ice Stream took place when the ice sheet terminated south of the Baltic depression.

The ice sheet melted away from Denmark and from parts of Skåne and Blekinge. It terminated in the Baltic depression between the islands of Bornholm and Öland. After this retreat, a lobe advanced in the Baltic depression. This lobe, which Holmström named the Low Baltic Ice Stream (in Swedish: 'lågaltiska isströmmen'), covered parts of Denmark and Skåne and the southeasternmost part of Blekinge (Plate 2E). Its extent in Skåne was roughly similar to the extent of G. De Geer's (1884, 1896) Baltic ice stream during the second glaciation (Plate 2C).

Holmström did not mention exactly how far to the north the ice sheet had retreated in Skåne and Blekinge during the advance of the Low Baltic Ice Stream. The extent of the ice sheet in the northern part of Skåne and in Blekinge is, therefore, only hinted at in Plate 2E.

3.6 Antevs 1915

Antevis (1915) determined the recession of the ice sheet in the northeastern part of Skåne and in the western part of Blekinge by means of a local varve chronology which was based on a large number of varve series. He had no problem in time correlating the individual varve series, due to the occurrence of an especially thick varve, nine subsequent varves of strongly-varying thicknesses and a change in the colour of the clay.

Antevis' recession lines showed the trend of the gradually northwardly receding ice margin for every 20 years (Plate 2F). He could only determine the trend of the ice margin a short distance south of Kristianstad, since not enough varve sequences were found further to the south. He concluded, however, that the ice sheet had receded from Ö. Sönnarslöv to the southernmost recession line shown in Plate 2F in about 120 years. The recession from this line to the northernmost recession line shown in Plate 2F took 200 years and the annual recession in this area was 90 m.

3.7 G. De Geer 1917

G. De Geer (1917) abandoned his earlier glaciation model (G. De Geer 1884, 1896). He now accepted Holmström's (1904) view that only parts of Skåne were deglaciated when a Baltic ice lobe, i.e. the Low Baltic Ice Stream, advanced here during the shrinkage of the

Scandinavian ice sheet. By means of a varve series from Rörum, De Geer related the extent of the Low Baltic Ice Stream in the south-eastern part of Skåne to the extent of the ice sheet in the northeastern part of province (Plate 2G).

De Geer had registered more than 1000 annual varves in a clay-pit at Rörum (Plate 2G). He considered that the extended deposits of sand at Rörum, which reach 50 m above the highest shoreline (Chapter 3.3), accumulated along with the varved clay in a local glacier-dammed lake. De Geer named this lake 'Rörumissjön' and believed that it had been dammed by the Low Baltic Ice Stream (Plate 2G) for about 1000 years. During this time, the ice sheet in the central and northern parts of Skåne receded toward the north.

The upper part of the varve series at Rörum was time correlated with the Gothenburg moraine (in Swedish: 'Göteborgsmoränen') on the Swedish West Coast. De Geer considered that the ice-marginal position indicated by this moraine continued from the Swedish West Coast through the northern part of Skåne along the Late Glacial shoreline (Chapter 3.3), Blekinge and Småland as far as Kalmar (Plate 2G). The varve series at Rörum showed that the ice margin continued from Kalmar to the area around Brösarp (Plate 2G).

A glacier-dammed lake, the 'Skåne-Kalmar issjön', was dammed between the Low Baltic Ice Stream and the northward-receding ice margin.

The trend of the ice margin presented in Plate 2G is compiled according to statements made by De Geer, as he did not present any maps.

3.8 Munthe 1910, 1920, 1940

Munthe's (1920) opinion of the ice streams in Skåne differed somewhat from Holmström's (1904). Similar to Holmström, Munthe believed that the ice sheet had a direction of movement from the east and the southeast in Skåne during the initial stages of the glaciation, i.e. an Old Baltic Ice Stream, prevailed here. However, Munthe combined Holmström's Meridian Ice Stream and High Baltic Ice Stream and called it the Northeast Ice Stream (in Swedish, 'NO-isen'). He was of the opinion that this ice stream prevailed during the main part of the glaciation. This ice stream was indicated by glacial striae in the central and northern parts of Skåne and by the occurrence of flint and mica quartzite in the till in the area northeast of Ystad (Plate 2I). According to Munthe, the provenance of the flint was the Cretaceous bedrock around Kristianstad and the provenances of the mica quartzite were located northeast of Kristianstad and northeast of Brösarp. During the shrinkage of the ice sheet, the Northeast Ice Stream was replaced by an easterly ice stream in the southeastern part of Skåne. This ice stream, which Munthe named the Intermediate Baltic Ice Stream (in Swedish: 'medelbaltiska isströmmen') preceded the Low Baltic Ice Stream.

Munthe (1940) described the recession of the ice sheet in Skåne and the extent of the Baltic Ice Lake. Munthe (1910, 1940) considered that the surface of the ocean was below the thresholds between the Danish islands and in the Öresund Sound (Plate 2A). Therefore, the Baltic depression was occupied by a glacial lake, the Baltic Ice Lake (in Swedish: 'Baltiska issjön'), during the deglaciation and not by the ocean, as was previous-

ly believed (cf. Chapter 3.3).

Munthe (1940) did not give the sources of information for lines 1-3 (Plate 2H) in my investigation area. These lines correspond to Munthe's (1940) E1, E2, and F lines.

Munthe (1940) considered that the glacier-dammed lake Rörumissjön (Chapter 3.7) occupied the area around Rörum and Brösarp (Plates 1 and 2H). The lake was drained at Djurröd, south of Andrarum, and at Lake Gyllebo sjö, southwest of Rörum. Munthe believed that the depressions here were eroded by the water from the glacier-dammed lake Rörumissjön.

According to Munthe (1940), almost all of the northeastern part of Skåne and Blekinge was covered by the Baltic Ice Lake, the highest metachronous level of which is marked in Plate 2H. The Baltic Ice Lake reached as much as 90 m a.s.l. in Blekinge and about 100 m a.s.l. in the northeastern part of Skåne and 20 m a.s.l. at Simrishamn immediately south of the area I have investigated.

3.9 Hansen 1933

Hansen (1933) investigated the clay-pit at Rörum where G. De Geer (1917) had registered about 1000 annual varves. He was of the opinion that only two clay laminae represented with any certainty the deposition of clay during the winter-half. The clay in the rest of the laminae had accumulated during the summer, when the discharge of meltwater from the ice sheet was low. Hansen estimated that the accumulation of the clay at Rörum had lasted about 30 years and not about 1000 years as De Geer had believed.

3.10 Ekström 1936

Ekström (1936) divided the till in Skåne into 'till provinces'. The basis of division was the lithological composition of the till which was mainly observed close to the ground surface. On the basis of the till provinces, Ekström considered it possible to determine the exact extent of the different Baltic ice streams which according to Munthe (1920) had existed in Skåne during the shrinkage of the ice sheet (Chapter 3.8).

Ekström distinguished four till provinces in the eastern part of Skåne (Plate 2I). The till in the individual provinces was predominated by fragments from the underlying bedrock (Fig. 57). The till in province 1 was made up mainly of igneous rock fragments derived from the area north of Kristianstad and the Linderödsåsen horsts. The till was limy where it was underlain by Cretaceous bedrock (province 1K). Mainly shale and igneous rock fragments constituted the till in province 2. Small amounts of Cambrian sandstone and Cretaceous flint also occurred in this till. The till in province 3 was predominated by Cambrian sandstone. In province 4, the till contained mainly shale, Cambrian sandstone and Cretaceous rocks derived from the local bedrock. Igneous rocks and Baltic indicators were also found here.

Ekström considered that the till in provinces 1-3 was deposited when Munthe's (1920) Northeast Ice Stream prevailed in Skåne. The absence of Baltic indicators showed that the accumulation did not take place in connection with ice movements from the east. The till in province 4 was deposited when an ice movement from the east prevailed, since Baltic

indicators occurred in that till. The northern boundary of province 4 indicated the northernmost extent of Munthe's Intermediate Baltic Ice Stream.

3.11 E. Nilsson 1942

E. Nilsson (1942) presented two recession lines for the eastern part of Skåne (Plate 2K). He considered, similar to G. De Geer (1917) and Munthe (1940), that a glacier-dammed lake, Rörumissjön, had existed in the area around Rörum. This glacier-dammed lake, was gradually transformed into a larger one during the recession of the ice sheet toward the north (Plate 2K: line 1). The lake was drained at Simrishamn and was indicated by beach deposits and bench marks at 100 m a.s.l. on the northern side of the Nävlingeåsen horst and at 65 m a.s.l. at Maglehem north-northeast of Brösarp.

Line 2 in Plate 2K shows the ice margin during an early phase in the development of the Baltic Ice Lake. Nilsson considered that the Baltic Ice Lake was drained into the ocean at Tyringe (Plate 2K) and later north of Tyringe.

In my investigation area, the trend of recession line 2 (Plate 2K) and the extent of the Baltic Ice Lake were based on beach deposits and bench marks. Nilsson had observed such features up to 121 m a.s.l. in the area north of Kristianstad and up to 55 m a.s.l. on the southernmost part of the hill of Ryssberget (Plate 2K). He explained the low levels on Ryssberget by a glacier lobe covering this hill when the area north of Kristianstad already was deglaciated.

3.12 Wennberg 1949

Similar to those geologists who earlier had dealt with the ice streams in Skåne, Wennberg (1949) considered that there was a Baltic ice lobe in the southern part of Skåne during the recession of the ice sheet (Plate 2L: inset). Unlike them, he was not of the opinion that the Baltic ice lobe represented an advance. It was instead the result of the fact that the movement of the ice sheet during the recession was controlled by the Baltic depression to a greater extent than earlier. North of the area covered by the Baltic ice lobe, the direction of movement of the ice sheet was from the east-northeast in Skåne and from the northeast in Småland.

Wennberg was of the opinion that the surface of the ice sheet had a constant slope and rose at most 3 m per 1 km along the flow lines. The surface melting was equal all over the ice surface. Due to the low surface slope, the mostly less than 200 m high horsts in Skåne had a great influence on the trend of the ice margin and resulted in stagnant ice, covering large areas in front of the receding, active ice sheet. For the same reason, the differences in height in the Baltic depression gave rise to stagnant ice, which prevented the existence of a large, continuous body of water here.

The ice-marginal line 1 in Plate 2L (Wennberg: the G line) was derived in the following way: Wennberg considered that the surface of the ice sheet in Skåne, north of the area covered by the Baltic ice stream, was an inclined plane that rose 1 m per 1 km toward the east-northeast. The surface became parallelly displaced toward the east-northeast dur-

ing the melting of the ice sheet. The junction between the surface of the ice sheet and the ground surface gave the positions of the ice margin. The junction between the ice surface and the Linderödsåsen horst northwest of Brösarp resulted in the northwest-southeast trend of the ice margin here (Plate 2L: line 1). The lobe in the area southwest of Brösarp (Plate 2L: line 1) followed, since this area is located about 50 m below the area northwest of Brösarp.

Wennberg was of the opinion that the till with Baltic indicators in the southeastern part of Skåne accumulated when the ice margin was in the position indicated by line 1 (Plate 2L). This also applied to G. De Geer's (1889a) upper till east of Brösarp (Chapter 3.3). The Baltic indicators showed that an ice movement from the east had prevailed during the deposition of the till. The fact that the predominating and youngest glacial striae around S:t Olof are northeasterly (Plates 1 and 2L) was explained in the following way. Based on Demorest (1943), Wennberg concluded that an ice sheet may have two simultaneous directions of movement: the surface direction of movement, controlled by the surface slope of the ice sheet, and the basal direction of movement, which is the largest and is controlled by the topography of the landscape. In the area around S:t Olof, the basal movement which eroded the bedrock was from the northeast. The simultaneous surface movement, which was from the east, transported indicators to the west.

When the ice margin was in the position indicated by line 2 (Wennberg: the H line) in Plate 2L, an ice movement from between the east and the southeast prevailed in the bay of Hanöbukten. Simultaneously, the northeastern part of Skåne was covered by stagnant glacier ice, which remained in front of the northeastward receding ice sheet in Småland (Plate 2L). The sedimentation of the stratified drift in the northern part of Skåne took place in or below glacier ice.

Line 2 in the area 1 have investigated was indicated only by ridges southeast and north of the peninsula of Listerlandet (Plate 2L). Wennberg believed that the ridges might be terminal moraines. The trend of line 2 was based mainly on the displacement of eskers after their formation and glacial striae in Blekinge, which Wennberg considered indicated an ice movement from between the east and the southeast in Hanöbukten Bay.

3.13 Bergdahl 1953

Bergdahl (1953) investigated ridges, mainly made up of till, eskers and the course of the deglaciation in the area around Häglinge and on the Linderödsåsen horst north and northeast of Andrarum (Plate 2M). The deglaciation in this area was subaerial.

The majority of the ridges described by Bergdahl were irregular and trended northwest-southeast, i.e. perpendicular to the glacial striae in the investigated area. They were mainly concentrated to a 1-3 km wide, 20 km long and northwest-southeast zone between Pärup, 6 km west-northwest of Långaröd, and a point located 5 km southeast of Andrarum. Bergdahl did not mention the width of the ridges, but stated that the length was 300-600 m with extremes of 1 km and that the height ranged from a couple of meters to 15 m. The ridges were made up mainly of till but ridges of, or containing, stratified drift were also observed. Bergdahl believed

that the ridges were formed near the margin of the ice sheet by pushing and by deposition of till and stratified drift in fractures in the ice.

Bergdahl described the morphology of and the stratified drift in the eskers that had been found during the geological mappings (Karlsson 1879, Tullberg 1882, G. De Geer 1889a, Munthe 1920). He described also some eskers not observed earlier and explained the genesis of the eskers on the basis of a modification of an already-known theory of esker formation (Strandmark 1889a, 1889b). The esker ridges were mainly formed in sub-glacial tunnels. The accumulation of the stratified drift here was favoured by glacier ice blocking the tunnels and by fractures in the tunnel roofs. Sometimes the sedimentation also took place where the tunnels were transformed into open channels. Bergdahl thought that the stratified drift which makes up the hummocky deposits that surround above all the large esker ridges was transported and deposited by meltwater streams flowing in several and communicating fractures in the glacier ice. These meltwater streams undermined the glacier ice which collapsed and thereby forced the meltwater to find new routes below, in or on the glacier ice.

Bergdahl excluded the possibility that the eskers on the Linderödsåsen horst were formed by supraglacial deposition of stratified drift for two reasons. Firstly, well-defined ridges would not have resulted if the accumulation of the stratified drift took place in channels that were not in contact with the substratum. Secondly, there was not enough drift on the ice surface to form eskers.

Bergdahl believed that the ice sheet was 'stiff' in its upper part and 'plastic' in the lower part. A zone of stagnant glacier ice arose in front of the active ice when the ice sheet, during the recession, had become so thin that the stiff ice came in contact with the substratum. Fractures which were mainly perpendicular to the ice movement direction were formed in the boundary zone between the stagnant and active ice.

Wennberg (1949) was of the opinion that the last ice movement was from the east in the area around Andrarum (cf. Plate 2K: line 1). Bergdahl considered, however, that the northwest-southeast trending zone of ridges here indicated a last direction of movement from the northeast.

3.14 E. Nilsson 1953

E. Nilsson's (1953) opinion about the recession of the ice sheet in southern Sweden, Denmark and the Baltic depression (Plate 2N: inset) was based mainly on Munthe's (1920, 1940) deglaciation model along with observations of the extent of the ocean and the occurrence of glacier-dammed lakes during the deglaciation. The glacier-dammed lakes were indicated by beach deposits, bench marks and sediments deposited in standing water. Ice-marginal positions were deduced from the extent and necessary damming of the lakes.

Nilsson considered that the glacier-dammed lake Rörumissjön was drained into a glacier-dammed lake occupying the area around Sjöbo (Plate 2N). This was indicated by depressions between the outlet of the glacier-dammed lake Rörumissjön and Sjöbo, where a large deposit of sand occurs. The depressions were believed to be erosion channels and the glaciofluvial deposit to be a delta, indicating a lake here. From the simultaneous existence of the

glacier-dammed lakes, Nilsson deduced the trend of the ice margin indicated by line 1 in Plate 2N.

According to Nilsson, saltwater from the ocean penetrated into the bay of Hanöbukten when the glacier-dammed lake Rörumissjön ceased to exist. This penetration continued until the ice sheet in the northeastern part of Skåne had receded to line 2 (Plate 2N). Beach deposits and bench marks on the northern slope of the Linderödsåsen horst showed that the ocean reached 73 m a.s.l. north of Brösarp and 84 m a.s.l. 25 km north-northwest of Brösarp. Nilsson based line 2 on his shoreline diagrams and the position of the ice margin in the western part of Skåne.

The Baltic Ice Lake filled the Baltic depression when the land upheaval had raised the thresholds between the Danish islands and in the Öresund Sound (Plate 2A) above the level of the ocean. Beach deposits and bench marks east and north of Kristianstad indicated that the Baltic Ice Lake reached about 100 m a.s.l. in the northeastern part of Skåne (Plate 2N). The trend of line 3 and 4 in the northeastern part of Skåne (Plate 2N) followed from the difference in level between the shore marks here.

Nilsson accepted G. De Geer's (1917) opinion that a Baltic ice lobe existed in Hanöbukten Bay when the central and northern parts of Skåne became deglaciated. This, the previous penetration of salt water into Hanöbukten Bay, and the difference in level between the shore marks in Skåne and Blekinge indicated that the ice sheet had the trend shown by lines 3 and 5 (Plate 2N).

3.15 E.H. De Geer 1954, 1957

E.H. De Geer (1954, 1957) described the recession of the Weichselian ice sheet on the basis of varve chronological investigations and relevant investigations by other geologists. The varve chronology in Denmark and southern Sweden was established among others by G. De Geer.

Recession line 1 and recession line 2 south of Brösarp (Plate 20) were based on E. Nilsson (1953). E.H. De Geer (1954) described but did not explain the northwest-southeast trend of line 2 northwest of Brösarp.

Line 3 (Plate 20) is north of Simrishamn according to G. De Geer (1917), except for that the ice lobe indicated by line 3 touched Skåne at Rörum and not at Brösarp (cf. Chapter 3.3). E.H. De Geer (1957) did not mention G. De Geer's (1889a) upper till at Brösarp, but stated that a till overlies the varved clay in the clay-pit at Rörum. This till was considered to have accumulated during an advance of the glacier lobe in Hanöbukten Bay. G. De Geer (1917) found more than 1000 annual varves in the clay-pit at Rörum, whereas E.H. De Geer (1954) stated that 840 measurable varves occur here.

3.16 E.H. De Geer 1962

E.H. De Geer's (1962) opinion about the recession of the ice sheet in Denmark, Skåne and in Hanöbukten Bay differed from her earlier opinions (Chapter 3.15). This was mainly due to a new compilation of investigations made by other geologists and only to a restricted extent to new varve chronological data.

Line 1 (Plate 2P) between Brösarp and Kabusa was based on a time correlation bet-

ween varved clay at Kabusa and the earlier mentioned varved clay in the clay-pit at Rörum (Chapter 3.3 and 3.15), which showed that these areas were deglaciated simultaneously.

E.H. De Geer did not state on what information she established lines 2-4 (Plate 2P). In the area around Kristianstad and in the western part of Blekinge, lines 5-7 were based on Antevs' (1915) recession lines (Plate 2F).

E.H. De Geer considered that the ice sheet receded from Rörum to the position shown by line 8 (Plate 2P) in 950 years. This and the trend of line 8 were established on the basis of G. De Geer's (1917) opinion about the deglaciation in the northeastern part of Skåne and in Blekinge and Småland (Plate 2G).

3.17 E. Nilsson 1960, 1968

E. Nilsson (1968) described the recession of the ice sheet in southern Sweden (Plate 2Q). The recession lines were based mainly on varve chronological investigations and, similar to earlier investigations (Chapter 3.11 and 3.14), on observations of the extent of the ocean and the occurrence of glacier-dammed lakes during the deglaciation. He considered in 1960 that the ice sheet formed a lobe in Hanöbukten Bay but did not discuss the deglaciation here in 1968. The recession lines which were presented in 1960 and 1968 were similar in the eastern part of Skåne. Nilsson's (1968) view on the penetration of salt water from the ocean into Hanöbukten Bay and the levels of the Baltic Ice Lake in the northeastern part of Skåne was the same as in 1953 (Chapter 3.14).

Similar to E.H. De Geer (1962), Nilsson obtained line 1 south of Brösarp (Plate 2Q) by time correlation between varved clay at Kabusa and the varved clay in the clay-pit at Rörum. Nilsson's (1968) varve diagrams from here are shown in Fig. 5. East of Brösarp, line 1 was not based on geological information from the southeastern part of Skåne.

Nilsson time correlated the varved clay at Kabusa and Rörum with varved clay on the plain around Kristianstad (Plate 2Q: inset). The three longest varve series from the plain (E. Nilsson 1968) are shown in Fig. 5.

The trend of line 2 (Plate 2Q) was not discussed by Nilsson. Line 3 corresponded east of Kristianstad to line 2 in Plate 2N (E. Nilsson 1953). Lines 3-5 in the area around Kristianstad were based on Antevs' (1915) recession lines (Plate 2F).

The lobate shape of line 5 and the circular shape of line 6 on the peninsula of Listerlandet and on the southernmost part of the hill of Ryssberget was based on the levels of beach deposits and bench marks, which showed that the highest level of the Baltic Ice Lake there was 52.5-55 m a.s.l., while in the rest of the northeastern part of Skåne and in Blekinge, they indicated a highest level of about 100 m a.s.l. This was thought to show that Listerlandet and the southernmost part of Ryssberget were deglaciated later than the surrounding areas (cf. Chapter 3.11).

Nilsson (1960) deduced the east-west trend of line 5 northeast of Kristianstad (Plate 2Q) in the following way. The Baltic Ice Lake was drained at Tyringe when the ice sheet no longer covered the low-lying area there. A 3-4 cm thick clay varve, which occurs in the varve series from the northeastern part of Skåne (Antevs 1915), was supposed to have formed when the surface of the Baltic Ice

Lake was lowered 10 m during the drainage at Tyringe. Since this varve was found only south of an east-west trending line through Tyringe, Nilsson deduced that the ice margin was parallel with this line.

Nilsson based lines 7 and 8 (Plate 2Q) on geological information from outside the area investigated.

3.18 Mörner 1969

Mörner (1969) described the course of the deglaciation in southern Sweden, Denmark and in the southern part of the Baltic depression. A part of Mörner's investigation area and the ice-marginal lines deduced by him are shown in Plate 2R. The ice-marginal lines

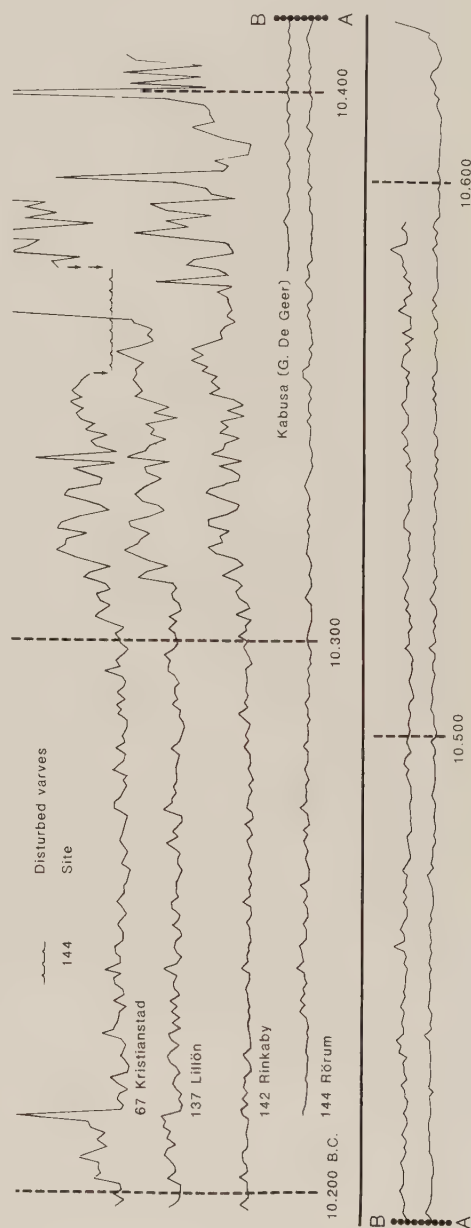


Fig. 5. Varve diagrams utilized by E. Nilsson (1968) to construct recession lines in the eastern part of Skåne (Chapter 3.17).

indicated readvances or standstills during the recession of the ice sheet.

Line 1 (Mörner: the G4 line) shows the maximum extent of the advancing Low Baltic Ice Stream west of Simrishamn (Plate 2R). Line 1 was in the area between Ystad and Simrishamn, based on lithological investigations by Holst (1892). Northwest of Simrishamn, line 1 followed the zone of ridges between Pärup and Andrarum (Plate 2M), described by Bergdahl (1953).

Mörner considered that line 2 (Mörner: the H1 line) was uncertain in the southeastern part of Skåne. Northwest of Brösarp, line 2 was indicated by northwest-southeast trending ridges described by Bergdahl (1953).

Mörner discussed two alternative positions for line 3 (Mörner: the H2 line) north of Rörum. The more probable is marked in Plate 2R and was indicated by the shoals of Kiviksbrädan, Söndre kar and Revhaken southeast of Åhus. Mörner believed that these shoals might be marginal, glacial deposits.

Lines 4 and 5 were based on Antevs' (1915) recession lines (Plate 2F).

Similar to Wennberg (1949), Mörner believed that the ridges southeast of the peninsula of Listerlandet (Plate 2R) might be terminal moraines and, therefore, suggested that the ice sheet had formed a lobe in Hanöbukten Bay.

Mörner (1969:125) stated that line 6 (Mörner: the Fjärås line) from the Swedish West Coast 'seems to continue towards the SE to the northern part of the plain Kristianstadslätten, where it turns eastwards to the big delta at Bredåkra'.

Mörner derived the continuation of lines 6 and 7 in Hanöbukten by datings which indicated that the island of Bornholm became deglaciated when the ice margin in southern Sweden was along lines 6 and 7.

3.19 Hellberg 1947, 1964, 1971

Hellberg (1947, 1964) showed that the large deposit of sand at Ljungarum (Plate 2S) which had been found during the previous geological mapping (Karlsson 1879) was a delta. Ridges observed by Hellberg 3 km southeast of Ljungarum and interpreted as terminal moraines indicated that the ice margin trended north-south in this area. Hellberg deduced, therefore, that the delta accumulated in a small glacial lake, the existence of which was due to damming of water between the Linderödsåsen horst and the Nävlingeåsen horst. The top surface of the delta showed that the glacier-dammed lake had reached 116 m a.s.l.

Hellberg (1971) investigated the highest level of the Baltic Ice Lake, the recession of the ice sheet and the glaciofluvial deposits in the area east-northeast of Kristianstad. The investigated area comprised the peninsula of Listerlandet, the area around Lake Ivösjön and the valley between Olofström and Lake Ivösjön (Plate 2S).

Hellberg concluded from an extensive investigation of beach deposits, bench marks and ice-marginal glaciofluvial deposits that the Baltic Ice Lake had reached 50-60 m a.s.l. in the investigated area. Munthe's (1940) and E. Nilsson's (1942, 1953, 1960, 1968) opinion that the Baltic Ice lake had reached about 100 m a.s.l. in the northeastern part of Skåne and the northwestern part of Blekinge was rejected by Hellberg.

Hellberg found that the youngest glacial striae on Listerlandet indicated an ice movement from between the north and the north-

east. This fact, an esker, and drumlins trending between the north-south and the northeast-southwest indicated that the last ice movement was from between the north and the northeast on Listerlandet. Therefore, Hellberg concluded that Wennberg's (1949) opinion on the recession of the ice sheet here was wrong (Chapter 3.12, Plate 2L).

According to Hellberg, the ice margin trended roughly east-west in the investigated area during the recession of the ice sheet, which followed from a shoreline diagram and the levels of the top surfaces of ice-marginal, glaciofluvial deposits.

Hellberg investigated the subaqueous esker in the valley between Olofström and Lake Ivösjön (Plate 2S). Morphological studies showed that it was 'beaded' and had formed in accordance with G. De Geer's (1897, 1940) theory on esker formation, i.e. the beads accumulated at the ice margin during the gradual retreat of the ice sheet.

3.20 Ringberg 1971, 1979

Ringberg (1971) dealt mainly with the glacial geology and the deglaciation in the eastern part of Blekinge but he also investigated 'proximal varves', i.e., varved sediments deposited near the margin of the ice sheet, in the northeastern part of Skåne.

Ringberg found that the youngest glacial striae in the eastern part of Blekinge were northerly and that the eskers had not been displaced after the formation. Therefore, he considered that Wennberg's (1949) opinion that a glacier lobe in Hanöbukten had influenced the eastern part of Blekinge (Chapter 3.12) was erroneous.

Ringberg investigated the limit between washed and unwashed till along 25 lines orientated perpendicular to the contour lines. Ringberg concluded that the Baltic Ice Lake had reached 63.6-67.5 m a.s.l. in the eastern part of Blekinge and not 85-88 m a.s.l., as Munthe's (1940) and E. Nilsson's (1968) three observations had indicated.

Ringberg (1971) investigated proximal varves at three sites in the northeastern part of Skåne. Two sites were located about 7 km south of Olofström and one site 16 km east of Kristianstad (Plate 2T). A 20-75 cm thick bed of ripple laminated sand and silt and a lamina of clay, some millimeters thick, constituted a proximal varve. The sand and silt accumulated during the summer and the clay during the winter. Ringberg found at the three sites in the northeastern part of Skåne and at six sites in Blekinge that 43-56 laminae and thin beds of alternating sand and silt made up the bed deposited during the summer. He concluded that the stratification in the summer layers had resulted from differences between the meltwater discharge during the night and the day.

Ringberg (1979) revised and extended Antevs' (1915) varve chronology in the northeastern part of Skåne and in the western part of Blekinge (Chapter 3.6, Plate 2F) and time correlated it to his varve chronology in the eastern part of Blekinge (Ringberg 1971). Ringberg's (1979) revised chronology was based on 185 varve series. The varve chronological investigations made it possible for him to present recession lines which showed the position of the gradually northwardly-receding ice margin at 20-year intervals (Plate 2T). The recession lines in the northeastern part of Skåne were in agreement with Antevs' (1915) lines. Like Antevs, Ringberg found that

the annual recession was about 90 m.

Weichselian ice sheet in southern Sweden.

3.21 Lagerlund 1977, 1980, 1981, 1983. Lagerlund et al. 1983

Lagerlund (1977) discussed investigations dealing with the ice streams in Skåne. He paid special attention to Holmström's (1904) ice stream theory. Lagerlund noted that although many of Holmström's key sites have been re-interpreted, his basic opinions about the ice streams have been adopted in later theories. Basic to Holmström's theory was that the different ice streams in Skåne were caused by changes in the position of the ice divide in northern Scandinavia. This view was founded on the assumption that the ice sheet was warm-based and that the glacial striae, remaining on exposed bedrock surfaces after the deglaciation, indicated a simultaneous ice movement from the centre to the periphery of the ice sheet. Lagerlund concluded that Holmström's interpretation of the glacial striae was incorrect and pointed to recent investigations indicating that the Scandinavian ice sheet might have been cold-based during the Weichselian.

Lagerlund (1980, 1983) developed a new glaciation model for the Weichselian ice sheet in southern Sweden, which was based mainly on a revision of the lithostratigraphy in the western part of Skåne (Lagerlund in Berglund & Lagerlund 1981). Lagerlund (1980) was the first to describe the growth of the ice sheet there. According to him, this took place via three 'outlet surges' which developed into marginal domes by capturing the accumulation of snow. Marginal domes also occurred during the maximum extent of and the shrinkage of the ice sheet. He deduced the following sequence of ice movement directions in Skåne, taken from the oldest to the youngest: from the southeast, from the northeast, from the north, from the northeast and from the south in the southern part of Skåne. The four first directions of movement prevailed during the main part of the glaciation.

Lagerlund (1980) presented one recession line that concerned the eastern part of Skåne (Plate 2U). The ice sheet formed a dome south of Simrishamn, which was indicated by Baltic indicators in the till along the coast south-southwest of Simrishamn, glacial striae on the island of Bornholm and Vortisch's (1972, 1973) investigations south-southwest of Simrishamn. Vortisch considered that the last ice movement was from the south there.

Lagerlund (in Lagerlund et al. 1983) presented a chronology for the recession of the

3.22 Stay 1979. Duphorn, Kögler & Stay 1981

Stay (1979) and Duphorn, Kögler & Stay (1981) investigated the varved clay in Hanöbukten Bay (Plate 2V). I refer below to Duphorn et al. (1981), since their work was based on Stay's (1979) and later investigations of the varved clay in Hanöbukten.

Duphorn et al. presented varve diagrams from six cores in Hanöbukten (Plate 2V: 1-6). Characteristic varve sequences and a change in the colour of the clay made it possible to time correlate the varve series in Hanöbukten with each other. These varve series were time correlated with a varve series from Österslöv, measured by Antevis (1915) and included in Ringberg's (1979) varve chronology.

Duphorn, Kögler & Stay's time correlations showed that the bottom varve in the varve series from Österslöv was deposited simultaneously with the bottom varves in varve series 1 (Duphorn et al.: core 14 115-5) and core 3 (core 10 113-7). The bottom varve in varve series 5 (core 14 830-1) was deposited 15 years after the bottom varve in the varve series from Österslöv. The substratum was not reached in core 2 (core 14 114-2) and core 4 (core 13 443-1) and core 6 (core 13438-1).

3.23 Other investigations

This section deals with unpublished examination papers from the Department of Quaternary Geology, University of Lund.

Dahlberg (1976), Malmberg (1976), L. Nilsson (1976) and Svensson (1976) found that the highest level of the Baltic Ice Lake was 52-57 m a.s.l. on the hill of Ryssberget (Plate 2X). This was concluded from mapping of beach deposits and from the level between washed and unwashed till, determined by soil sampling along lines trending perpendicular to the contour lines.

Dupuy (in prep.) found by the same methods as used in the investigations above that the highest level of the Baltic Ice Lake in the southern part of the island of Ivön (Plate 2X) was 55 m a.s.l.

Thuning (1980) investigated the deglaciation in the area around Degeberga (Plate 2X) and determined that the Baltic Ice Lake there reached 57 m a.s.l.

4.1 Maps, air photographs and location of sites

Almost all of the Kristianstad area is covered by geological maps published in the Aa-series of the Geological Survey of Sweden (SGU). They have a scale of 1:50 000. The following maps concern my investigation area: Aa 61 (Lindström 1877), Aa 68 (Karlsson 1879), Aa 85 (Nathorst 1882), Aa 86 (Tullberg 1882), Aa 103 (G. De Geer 1889), Aa 105-107 (G. De Geer 1889), Aa 108 (Blomberg 1892), Aa 109 (Holst 1892) and Aa 142 (Munthe, Johansson & Grönwall 1920). The only available geological map in the northeastern part of the Kristianstad area is the geological map Ca 1 (Blomberg 1900), which is less detailed than the maps in the Aa-series.

The southernmost part of the Kristianstad area has recently been remapped by the SGU. The maps which soon will be published in the Ae-series of the SGU (Daniel in prep.), were kindly placed at my disposal before the publication. The maps in the Ae-series are very exact, have contour lines with a contour interval of 5 m and have a scale of 1:50 000.

The maps described above show bedrock exposures, glacial striae, glacial deposits and postglacial deposits. On the maps in the Aa- and Ca-series different kinds of rocks are also distinguished. A modern bedrock map (Kornfält, Bergström, Carserud, Henkel & Sundquist 1978) covers a part of my investigation area. It is published in the Af-series of the SGU and has a scale of 1:50 000. All of the investigated area and the rest of Skåne is covered by a bedrock map with a scale of 1:250 000 (Bergström & Shaikh 1980, 1982).

The topographical basis of the maps in the Aa-series and of the map Ca 1 is out-of-date and contour lines are missing. Their geological information is still valid, however, and was along with information yielded from air photo interpretation, field controls, the maps by Nilsson & Gustavsson (1967), K. Nilsson (1968), Rydenheim (1973), Gustavsson, Andersson & De Geer (1979) and well bore logs stored in the SGU archives in Lund, was transferred to the Topographical Map of Sweden (Topografiska kartan över Sverige). The Topographical Map of Sweden is a modern and exact map with a scale of 1:50 000 and contour lines with a contour interval of 5 m. The geological map in Plate 1 is a simplified version of the so-obtained geological map and the map in SGU's Ae-series. This is also valid for the other geological maps presented in this investigation apart from those covering areas I have remapped.

The topographical maps in this work are based on the Topographical and Economical Maps of Sweden. The Economical Map of Sweden (Ekonomiska kartan över Sverige) has a scale of 1:10 000 and contour lines with a contour interval of 5 m.

All of the investigated area was cross-checked with the help of air photographs in order to control the old geological maps and to obtain information not set out in these maps. The air photographs are issued by the Natural Land Survey of Sweden (Statens lantmäteriverk) and have a scale of 1:30 000. The interpretation of the air photographs was carried out in a Topcon stereo interpretoscope.

The location of sites described in this work are given in a coordinate system, named

'Rikets nät' and marked on the Topographical Map of Sweden. The coordinates of the sites are presented in Appendix 3, as are also the coordinates of lithological analyses that were not taken at sites described in the text.

4.2 Geological mapping

The glaciofluvial deposits were remapped in selected areas. The mapping in subarea 6A-D (Plate 4) and in parts of subarea 7F (Fig. 50) was performed in accordance with the rules stated by the SGU. Subareas 1A, 2B, 3B, 5A and 5B (Plate 3) was mapped in less detail. Apart from in subarea 1A, the main purpose of the mapping in these subareas was to find the exact position of and to describe the morphology of the ridges of stratified drift occurring here.

4.3 Seismic investigations

Seismic investigations were carried out with a single channel Bison Signal Enhancement Seismograph model 1570B, used for refraction seismology. The seismic registering took place along 60 m long profiles and, except for in one case, also along reverse profiles of the same length. The seismic velocities and the depth to the first two interfaces were determined by nomographs issued by Bison Instruments Incorporated.

The following abbreviations are used when the seismic investigations are presented:

X1: Distance to the first intersection in the seismic graph.

X2: Distance to the second intersection in the seismic graph.

V1: Seismic velocity in the uppermost stratum.

V2: Seismic velocity of the intermediate or bottom stratum.

V3: Seismic velocity in the bottom stratum.

D1: Thickness of the uppermost stratum.

D2: Thickness of the intermediate stratum.

D2min: Minimum thickness of the bottom stratum.

An 'r' is added to denote reverse profiles.

The seismic velocities indicate the following types of soil or bedrock:

Less than 500 m s⁻¹: Drift above the groundwater table.

500-1000 m s⁻¹: Sand and gravel below the groundwater table.

1000-2000 m s⁻¹: Till below the groundwater table.

3000-4000 m s⁻¹: Sedimentary bedrock or fractured crystalline bedrock.

More than 4000 m s⁻¹: Crystalline bedrock.

These relations are mainly the result of seismic investigations carried out at the Department of Quaternary Geology, University of Lund.

4.4 Classification of sedimentary structures in stratified drift

The classification of sedimentary structures in stratified drift is based mainly on classifications by McKee & Weir (1953), Allen (1968), Jopling & Walker (1968) and Potter & Pettijohn (1977). The terms stratum, cross-

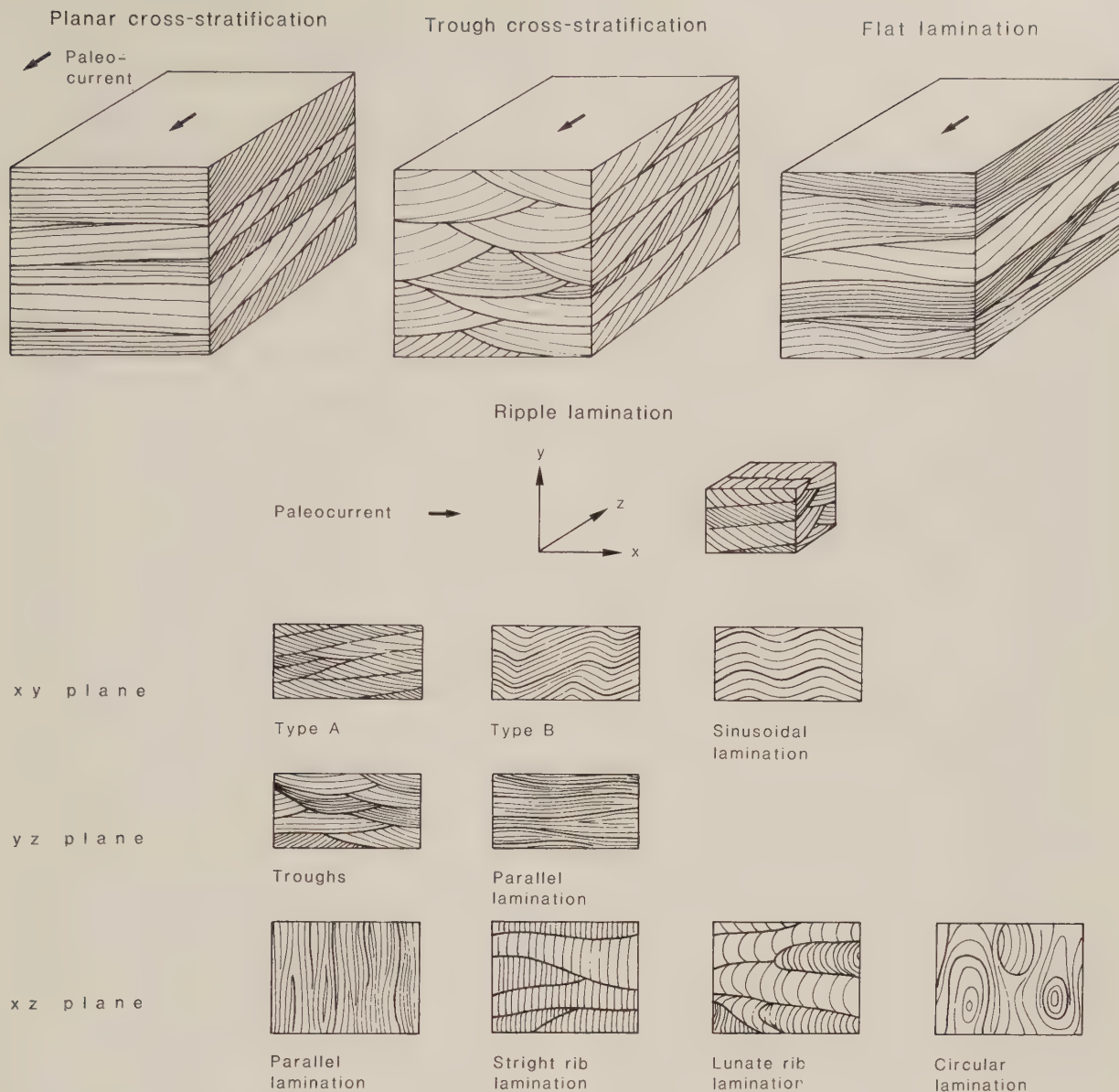


Fig. 6. Classification of stratified drift used in this work.

stratum, bed, laminae and set are used in accordance with McKee & Weir (1953).

It is not possible to describe all sedimentary structures in stratified drift using only the terms bed (cross-bed) and laminae (cross-laminae). Therefore, four types of stratification and cross-stratification of common occurrence are distinguished: trough cross-stratification, planar cross-stratification, flat lamination and ripple lamination (Fig. 6).

Allen (1968) found that bed forms causing cross-stratification have a different length: height ratio depending on whether their height is greater or less than 4 cm. By means of this discovery, he could distinguish between largescale ripples (dunes, megaripples) and smallscale ripples (ripples), and could classify cross-stratification as largescale if the set thickness in a cross-stratified unit was greater than 4 cm and as smallscale if it was less. I follow this basis of division but have replaced the term smallscale cross-stratification with ripple lamination. The term ripple lamination is simpler to use and is preferable to Jopling & Walker's (1968) terms ripple cross-lamination and ripple-drift cross-

lamination, because it involves more than cross-lamination (Fig. 6).

Two types of largescale cross-stratification have been distinguished according to Potter & Pettijohn (1977), i.e., planar cross-stratification and trough cross-stratification (Fig. 6). Two terminological examples follow. A '0.5 m thick bed with trough cross-lamination' means that the individual trough sets are made up of less than 1 cm thick strata, i.e. laminae. A '3 m thick bed with trough cross-bedding' indicates that the individual trough sets are made up of more than 1 cm thick strata of sand, i.e. beds.

A bed with flat lamination (Fig. 6) implies a bed made up of laminae parallel to or inclined less than 10° to the extension of the bed. Harms & Fahnestock (1965) called flat lamination 'horizontal stratification' and Banerjee & McDonald (1975) named it 'horizontal bedding'. I have not used the word horizontal lamination since cross-beds, constituting delta foreset beds, were often found to be laminated parallel to their extension.

The ripple lamination was classified in two vertical and one horizontal plane (Fig.

6) according to Allen (1968). One of the vertical planes (the xy plane) is orientated parallel to the paleocurrent direction that gave rise to the ripple lamination and the other (the yz plane) is orientated perpendicular to this plane. The horizontal plane is named the xz plane. Allen (1963a, 1963b) considered that a relation existed between the lamination in these three planes and distinguished between four types of ripple lamination or smallscale cross-stratification. I have, however, described the lamination in the three planes individually. The investigated ripple lamination varied especially in the horizontal plane and a definite relation was not found between the lamination here and the lamination in the vertical planes. The lamination in the xy plane (Fig. 6) was classified according to Jopling & Walker (1968). The lamination in the yz plane and the xz plane was classified partly according to Allen (1968) and partly according to my own investigations. If the observed lamination was wavy or irregular, these words are added before the description of a specific type of ripple lamination.

The terms topset bed, foreset bed and bottomset bed are used in connection with deltas. These beds are described in further detail by means of the classification presented above.

4.5 Grain size, sorting and roundness

The grain size was classified according to the size grade scale in Fig. 7.

The boulder and stone content in till was estimated in the field. The boulder content was classified as high if boulders constituted more than 1/3 of the total volume of the till, moderate if between 1/3 and 1/8 and low if less than 1/8. The stone content was classified in the same way.

The boulder content was not estimated in stratified drift and it can only be stated that boulders occur in varying amounts in stony gravel and stony gravelly sand.

For sizes less than 20 mm, the clay content of tills is stated in the following way: the till is a sandy till if the clay content is less than 5%, a clayey till if 5-15% and a clay till if more than 15%.

The grain size composition for sizes less than 20 mm was determined either in the field or in the laboratory. In the laboratory, sizes between 20 mm and 0.063 mm were sieved, using phi-sieves spaced at half-phi intervals. The grain-size composition for sizes less than 0.063 mm was determined by either hydrometer analysis (Gandahl 1952) or a SediGraph 5000E particle analyzer (Micrometrics Instruments Corporation, U.S.A.). Investigations carried out by L. Barnekow of the Department of Quaternary Geology, University of Lund, have shown that hydrometer analysis and analysis with the SediGraph 5000E give identical results.

The degree of sorting has been classified according to Trask (1932) who distinguished well-sorted, normally-sorted and poorly-sorted sediments. The degree of sorting was estimated in the field by visual examination.

Boulder	coarse	600 mm
	fine	200
Stone	coarse	60
	fine	20
Gravel	coarse	6
	fine	2
Sand	coarse	0.6
	medium	0.2
	fine	0.06
Silt	coarse	0.02
	medium	0.006
	fine	0.002
Clay		

Fig. 7. Size grade scale used in this work.

The roundness of stones was determined according to Powers (1953), who classified particles as very angular, angular, subangular, subrounded, rounded and well-rounded.

4.6 Lithological analyses

The lithological composition of till and stratified drift was determined for the sizes 3-4 mm and in some cases for the sizes 4-11mm. The sizes 3-4 mm were chosen, because it was difficult to distinguish between bedrock fragments less than 3 mm in diameter and because the lithological analyses began in a clay till with mainly small amounts of fragments with a diameter greater than 4 mm. Most of the subsequent analyses of till with a higher content of gravel and of stratified drift were made using the same fraction in order to make lithological comparisons possible.

The number of counted grains was about 500 in each sample, but the amount varied between 115 and 2017. It is generally accepted that about 500 grains give significant results (J. Lundqvist 1952; Dreimanis & Reavely 1953; Virkala 1958; Lidén 1975).

The lithological determinations were made by means of a binocular microscope, with a magnification of 8-40X.

5 The Linderödsåsen horst

The northeastern and eastern sides of the Linderödsåsen horst are steep, 75–100 m high and incised by as much as 75 m deep valleys (Plate 1). The top surface of the horst between Ylleröd in area 1 and Andrarum in area 7 is gently undulating. The relative relief here is mostly less than 25 m and the ground surface slopes toward the southwest and the northeast from the crest line of the horst, which passes through Ylleröd and a point located 2 km southwest of Hörröd in area 6. The relative relief is for the most part less than 25 m in the area east and southeast of Andrarum, apart from the valley in which Brösarp (area 7) is situated and the depression at Rörum (area 9). The valleys and depressions on the horst trend mainly north-east-southwest but valleys and depressions trending northwest-southeast and north-south are also found.

Gneiss and gneissic granite make up the greater part of the horst (Fig. 57). Sandstone, shale and alum shale are found in the area around Andrarum and along the eastern border of the horst (Fig. 59). Cretaceous rocks consisting of limy sandstone, sandy limestone and limestone outcrop northeast and east of the horst.

The glacial striae give evidence for a youngest ice movement from between the north-northeast and the east-northeast except in the southeastern part of area 9. Ice movement directions from the east and the south are registered by the striae and crescentic fractures occurring here. The age relation between the individual directions has not completely been made clear in this area. Striae in areas 8 and 9 suggest that an ice movement from the north preceded the ice movement from the northeast here.

Well bore logs show that the till on the horst is mostly less than 10 m thick. Till beds that are up to 30 m thick occur below the sand northeast and east of the horst. In the main, the till on the horst forms a cover that reflects the irregularities of the underlying bedrock. However, some of the mounds and irregular ridges that occur here are made up of till. The mounds are 100–400 m in diameter and 5–10 m high. The ridges have varying orientation, are 300–800 m long, 100–300 m wide and 5–10 m high. Hummocks of till about 5 m high and with a diameter that varies between 50 and 100 m are found especially in the area northwest of Hörröd. Bergdahl (1953) described till-ridges, trending northwest-southeast, that were concentrated mainly to a zone between Pärup, 6 km west-northwest of Långaröd, and a point located 2 km southeast of Andrarum (Chapter 3.13). I have not been able to locate these ridges aside from a distinct northwest-southeast trending ridge located 2 km southeast of Andrarum. The other ridges that occur in the zone described by Bergdahl are of varying orientation and resemble the irregular ridges on the rest of the horst.

The till on the horst is mainly sandy where the bedrock is composed of gneiss, gneissic granite and sandstone. The exception is the areas southeast of Brösarp and north of Rörum where sandy till, clayey till and clay till rest on gneiss. The clay till in the valley east of Brösarp is underlaid by sand. The clayey till and clay till in the areas southeast of Andrarum and south of S:t Olof

rest on shale and alum shale.

Stony gravelly sand and sand make up the glaciofluvial deposits on the Linderödsåsen horst. The deposits are mainly located in valleys, depressions or between bedrock-induced mounds, and trend northeast-southwest.

The stony gravelly sand forms ridges and extended hummocky deposits. The ridges have triangular cross-sections, are 50–1000 m long, 10–100 m wide and 2–15 m high. Hummocks, mounds, plateaus, short and irregular ridges of varying orientation and thin covers of stratified drift constitute the extended deposits. The hummocks are 25–100 m in diameter and 2–5 m high. The mounds are 100–300 m in diameter and 5–15 m high. The plateaus have even and roughly horizontal surfaces and are of varying shape and size. The short and irregular ridges have a length:width ratio that is less than 3:1. They are 50–500 m long, 30–300 m wide and 3–15 m high. The thin covers of stratified drift follow the morphology of the substratum and are at most some meters thick.

Glaciofluvial deposits predominated by sand occur in the valleys in the eastern part of the horst. The sand contains gravelly sand, silt and strata of clay. The sand reaches 125 m a.s.l. northeast of Hörröd, about 105 m a.s.l. north and west of Brösarp and about 80 m a.s.l. south of Rörum. The surface of the deposits is hummocky or even and the deposits are often dissected by brooks.

Varved clay occurs northeast and east of the slope of the Linderödsåsen horst.

Large beach deposits of stony gravelly sand are found on the eastern slope of the Linderödsåsen horst. According to G. De Geer (1889a), they reach up to 41.8 m a.s.l. north-northeast of Brösarp and up to 32.3 m a.s.l. north of Rörum. The deposits southwest of Rörum (Daniel in prep.) reach up to between 20 and 25 m a.s.l. according to the Topographical Map. E. Nilsson (1953, 1968) stated that bench marks and beach deposits occur between 39.0 and 83.0 m a.s.l. about 5 km northwest of Ö. Sönnarslöv, at 75.7 m a.s.l. at Ö. Sönnarslöv, between 30.0 and 81.5 m a.s.l. about 2 km northwest of Degeberga, at 45.0 m a.s.l. at Degeberga, at 44.6 m a.s.l. about 4 km southeast of Degeberga, and between 11.8 and 81.5 m a.s.l. about 6 km southeast of Degeberga. Investigations by Thuning (1980) showed that the bench marks and beach deposits observed by Nilsson in the area around Degeberga do not exist. Bergdahl (1953) observed bench marks situated at about 83 m a.s.l. in the area 5–10 m northwest of Ö. Sönnarslöv. I have not been able to locate these bench marks.

I have divided the Linderödsåsen horst into nine areas (Plate 1) which are described at length below.

5.1 Area 1. The Ylleröd area

5.1.1 General description

Northeast of Linderöd, a 50 m deep valley dissects the northeastern slope of the horst (Fig. 8B). This valley continues from immediately northwest of Linderöd toward the south-southwest and in this area the horst is about 1 km wide and 15 m deep. The area surround-

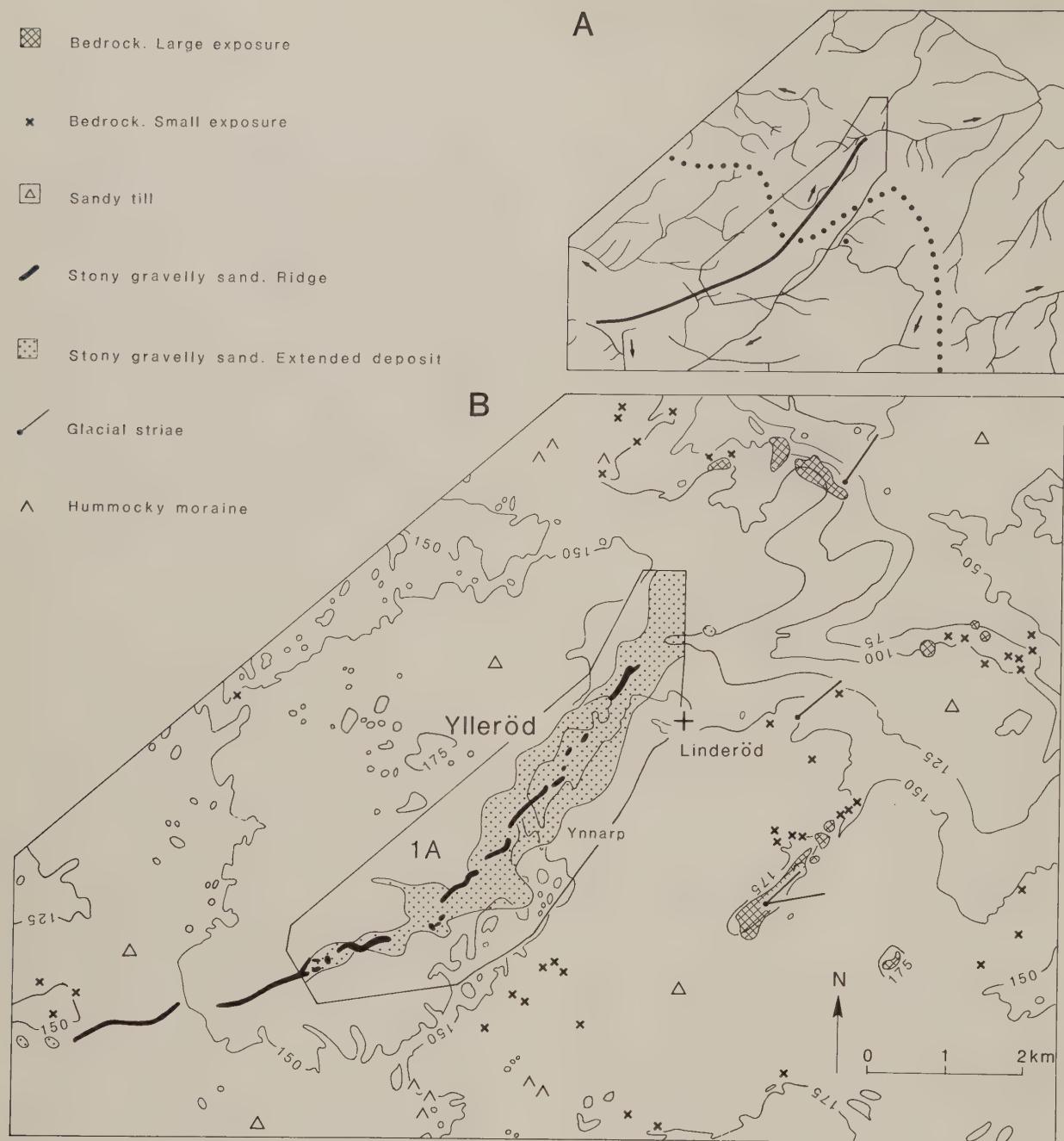


Fig. 8. Area 1, the Ylleröd areas. A. The fluvial drainage pattern and the main watershed. The zone with ridges of stratified drift is indicated by a continuous line. B. Geology and morphology. The contour interval is 25 m. Subarea 1A is indicated.

ing the valley is irregularly undulating, which is reflected by the fluvial drainage pattern (Fig. 8A). The relative relief here is less than 15 m. Bedrock exposures are sparse except for along the northeastern slope of the horst and southeast of Linderöd in connection with a dolerite dike. Three sites with glacial striae indicate an ice movement from between the northeast and the east-northeast. The northeasterly striae 3 km southeast of Linderöd are reported by Bergdahl (1953). The glacial deposits in area 1 are predominantly sandy till, which is about 5 m thick. Glaciofluvial deposits of mainly stony gravelly sand making up a northeast-southwest trending zone occur in the central part of the

area. Northeast of Ynnarp they are located in the valley with a northeastward sloping floor occurring here. The deposits cross the watershed at Ynnarp and are located southwest of Ynnarp between bedrock-induced mounds in a gently undulating landscape.

I have remapped the glaciofluvial deposits in subarea 1A; this area is shown in Plate 3.

5.1.2 Subarea 1A. Description

The area covered by till

The ground surface in this area is undulat-

ing and the relative relief is mostly less than 10 m (Plate 3). Depressions alternate with irregular mounds which have gently sloping sides. The mounds, which mainly consist of bedrock covered by till, are 200-300 m in diameter and 5-10 m high. Some hummocks of till, 25-75 m in diameter and less than 2-5 m high, also occur.

The minor bodies of stratified drift that were found in this area are not marked in Plate 3. Observed exposures, which were small and shallow, displayed gravel and sand.

The till is sandy, poorly sorted and the stone and boulder content is moderate. The exposures are small. One of them, site 1, is described in Chapter 5.1.3.

The extended deposits of stony gravelly sand

Although this area is predominated by stratified drift, till occurs within minor areas. These minor areas have not been marked in Plate 3.

The morphological elements are hummocks, mounds, plateaus and gently undulating ground.

The hummocks are 25-75 m in diameter and 2-5 m high. They are mostly found in groups, but are sometimes isolated. Hummocks lying closely together may vary greatly in size and a large hummock may be composed of several small ones. Therefore, the Δ -sign in Plate 3 usually denotes more than one hummock. The hummocks are mostly made up of stratified drift, but may contain or mainly consist of till. The steeper their sides and the closer they are to the ridges of stony gravelly sand described below, the more likely they are to be predominated by stratified drift.

The mounds are 5-10 m high and 100-200 m in diameter. The absence of exposures makes it impossible to judge their internal composition.

Exposures show that the two plateaus found in subarea 1A are made up entirely of stratified drift. The southern plateau is located immediately east of the peat bog Stass mosse where site 2 occurs. It is about 300 m in diameter, up to 7 m high and its top surface is horizontal. The northern plateau is situated about 800 m east-northeast of Ylleröd. Site 6 is located in the central part of the plateau, which has a 300x100 m large, horizontal and even surface. The sides of the plateau are steep except for the southwestern side, which is gently sloping. Site 5 is located in this slope.

The stratified drift with a gently undulating surface forms a cover on the till that is less than about 2 m thick.

Some of the exposures occurring in this area are described in Chapter 5.1.3.

The ridges of stony gravelly sand

The ridges have triangular cross-sections, are 75-800 m long, 40-75 m wide and 5-10 m high. The individual ridges have tapering ends and vary in size. The size variations may be small, less than 10 m in width and a few meters in height. Larger variations result in a more or less marked segmentation of a ridge. The variations in width and height are independent of the position in the landscape of the ridges. The ridges rise above and do not merge into the surrounding deposits of stratified drift.

Stony gravelly sand with a varying amount of boulders was observed in pits and road-

cuts located in the ridges. It was not possible to discern any stratification, as only small sections not covered with scree occur.

5.1.3 Exposures

The location of the sites is marked in Plate 3.

Site 1 - A 10 m long and 2 m deep road-cut, which is located in a hummock of till that is 30 m in diameter and 2 m high. The till consists of sandy and poorly sorted material with a moderate boulder and stone content (Appendix 2: L1). Boulders and stones are subangular.

Site 2 - Two gravel-pits located in a plateau make up this site. The southern pit is 200x70 m large and the height of the pit-walls is 2-5 m. Only a 5x5 m large, vertical surface was not covered by scree. Horizontal beds of stony gravelly sand and gravelly sand alternated here. The northern pit is 150x15 m large and 7 m deep. All the walls are covered by scree composed of stony gravelly sand.

Site 3 - A 4x4 m large and 2 m deep till-pit situated in a 2 m high hummock. Scree covers the pit-walls apart from some small surfaces, where a sandy, poorly sorted material (Appendix 1 G1) displaying a diffuse and irregular stratification is exposed. Stones and boulders are angular to subangular and occur in moderate amounts.

Site 4 - A 50x50 m large and 4 m deep sand-pit situated in a hummock which is 2 m high and 75 m in diameter. The sections show a 1 m thick bed of gravelly sand underlain by a 3 m thick sequence of horizontally bedded sand.

Site 5 - A 75x40 m large and 4 m deep gravel-pit with beds of stony gravelly sand and sand (Appendix 2: L2), dipping 5° toward the south. Ripple lamination in the sand (xy plane: type A, yz plane: troughs) indicates a paleocurrent from 0° on an average.

Site 6 - A 250x100 m large and 10 m deep gravel-pit. The pit-walls are mostly covered by scree, but some fresh surfaces show horizontal beds of stony gravelly sand and sand to a depth of 5 m below the ground surface. Rydenheim (1973) observed horizontal beds of alternating coarse and fine material in this pit. According to him, sand and silt occurred in up to 1 m thick beds.

Site 7 - A 400x80 m large gravel-pit with up to 2 m high pit-walls. The pit is located in a ridge which was described by Rydenheim (1973) and is by now almost removed. The sections show horizontal beds of stony gravelly sand, gravelly sand and sand. Flat lamination and trough cross-lamination occur in the gravelly sand (Appendix 2: L3). The cross-lamination indicates a paleocurrent from 45° and the ripple lamination (xy plane: type A, yz plane: troughs) in the sand displays the same paleocurrent direction.

5.1.4 Discussion

The drainage of the ice sheet

The zone with glaciofluvial deposits in area 1 is located in a 15 m deep valley between Linderöd and Ynnarp and between less than 15 m high bedrock-induced mounds southwest

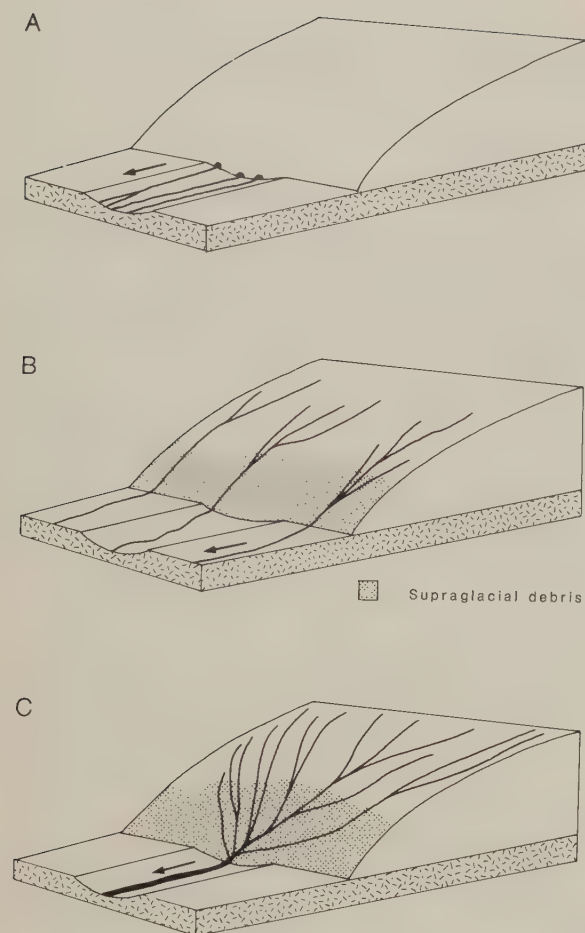


Fig. 9. The influence of a shallow valley on the drainage of an ice sheet. A. A subglacially drained ice sheet. The drainage is controlled by the valley beneath the ice sheet. B. A supraglacially drained ice sheet with a surface without depressions. The valley does not influence the meltwater drainage. C. A supraglacially drained ice sheet with a depression that concentrates the surface meltwater into one large stream. Such a stream would only occasionally be controlled by the valley.

of Ynnarp. The zone is directed toward the 75 m deep valley mouth north-northeast of Linderöd. This is possible to explain if the drift which makes up the glaciofluvial deposits was transported by subglacially flowing meltwater (Fig. 9A), since a landscape with low relief may influence such a drainage. The subglacial drainage took place in an up-slope direction northeast of Ynnarp and did not follow the valley south-southwest of Ynnarp, which means that the drainage not only was controlled by the topography of the landscape in area 1 but also by the ice sheet itself. Consequently the ice sheet had a sloping surface (Fig. 9A), since it is not probable that an ice sheet with a horizontal surface and a sloping water table caused the up-slope transport of the meltwater. The stratified drift making up the extended glaciofluvial deposits in area 1 ought to have accumulated at the front or immediately inside the front of an ice with a horizontal surface, since the accumulation took place either in a disintegrating part of the

ice sheet or on less than about 10 m thick glacier ice (see below). Therefore, the horizontal ice surface cannot have been located more than about 10 m above the levels reached by the extended deposits in area 1. This makes an up-slope transport of meltwater impossible, since the water table of the ice sheet cannot have reached above the ice surface. This conclusion is also valid for the other parts of the Kristianstad area where the ice sheet was drained in an up-slope direction.

The relationship between the stratified drift and the morphology in area 1 described above would not have resulted if supraglacial meltwater streams deposited stratified drift in area 1 and the ice sheet had a sloping surface without depressions (Fig. 9B). Instead, the supraglacial drainage would have resulted in a large number of small glaciofluvial deposits, dispersed throughout area 1 and located both in the depressions and on the heights. This follows, since the large number of debris-transporting meltwater streams that ought to have occurred on the ice surface would not have been concentrated into one large stream by the morphology of the landscape. A multi-channel drainage cannot have been transformed into a single-channel drainage on the ice sheet, as none or only some heights in area 1 can have protruded above the ice surface. It is also unlikely that the meltwater streams were concentrated into one large stream proglacially, along the front of the ice sheet or in a zone of stagnant ice. The relief is irregularly undulating in area 1, and because of that the accumulation of the stratified drift would have taken place before the debris transporting meltwater streams reached the valley where the glaciofluvial deposits are found.

The supraglacial meltwater streams might have been concentrated into one meltwater stream if a large depression had occurred in the ice surface (Fig. 9C). Such a depression is, however, not likely to have existed either when the stratified drift in area 1 or in the rest of the Kristianstad area accumulated. The differences in height in the landscape are too small to have had an influence on the shaping of the ice sheet. It is improbable for two reasons that a meltwater stream eroded a deep channel in the ice, joined with other streams which on their part eroded and melted the ice sheet and ultimately created a depression. Firstly, such depressions have not been observed in the ice surface of present-day glaciers. Secondly, it is not likely that the depressions would have resulted in deposition of glaciofluvial sediments only in the low-points of the landscape in area 1 or in the rest of the Kristianstad area.

Considering the relief in area 1, an englacial transport of meltwater and sediments in tunnels located less than 5–10 m above the base of the ice sheet might have been controlled by the morphology of the landscape and, thereby, have resulted in deposition of the sediments in low points in area 1. However, it follows from the discussion below that such a drainage is not plausible. Englacially-occurring meltwater must have been produced at the base or at the surface of the ice sheet. If the meltwater was produced by basal melting, it ought to have flowed mainly subglacially. If the meltwater was produced by surface melting and the ice sheet was at the pressure melting point, it is likely that the meltwater reached the base of the ice sheet and flowed here. Surface meltwater penetrating only a part of the ice sheet is possible, if the temperature was below the

pressure melting point in the basal parts and at the pressure melting point higher up in the ice sheet. However, an englacial drainage is not plausible in this case, since the meltwater probably would have been transformed into ice when it came in contact with the glacier ice below the pressure melting point. Also the fact that supraglacial drift ought to have been transported down into the ice sheet along with the meltwater makes it improbable that the drift which constitutes the glaciofluvial deposits in area 1 was transported in englacial tunnels by supraglacial meltwater. Transportation of supraglacially-derived drift in englacial tunnels ought to have taken place, since the amount of englacial drift occurring in connection with the englacial tunnels must have been too small to form the glaciofluvial deposits in area 1. However, the meltwater which deposited the glaciofluvial sediments in area 1 was derived from a part of the ice sheet that was not disintegrated (see below); thus the penetration of surface meltwater ought to have taken place between the ice crystals (Shreve 1972). This means that drift cannot have been transported down into the ice sheet.

The discussion above about the englacial drainage of the ice sheet is valid not only for area 1, but also for the rest of the Kristianstad area.

Observations of present-day glaciers show that the amount of meltwater produced at the surface of a glacier is larger than the amount produced at the base (e.g. Sugden & John 1976). This was probably also the case during the recession of the ice sheet in area 1, although the meltwater produced by surface melting did not transport or only transported small amounts of sediments when it flowed down the ice surface. It is likely that surface meltwater penetrated the ice sheet and flowed along its base during the deposition of the glaciofluvial sediments in area 1, since the basal production of meltwater results only in insignificant meltwater streams at present-day glaciers (Stenborg 1965; Paterson 1969; Boulton & Vivian 1973).

The accumulation of the stratified drift

The ridges of stratified drift were undoubtedly formed in a stagnant part of the ice sheet, as they are winding and their morphology does not show any signs of disturbance from active ice. The stratified drift making up the ridges accumulated in connection with glacier ice that was not disintegrated, since the ridges do not form gradual transitions to the extended deposits of stratified drift. Further, they indicate a conduit, not formed by disintegration of the ice but by the flow of meltwater. It was earlier concluded that the sediments making up the glaciofluvial deposits in area 1 were transported along the base of the ice sheet. From this it follows that till or bedrock constituted the base of the meltwater conduit indicated by the ridges, and due to this, that also the drift in the ridges accumulated directly on till or bedrock without intervening glacier ice.

During the surface melting of the ice sheet, the tunnel indicated by the ridges in area 1 ought to have been transformed into an open channel. Since the ice sheet had a sloping surface, it is likely that this transformation took place by gradual stages toward the northeast. A great decrease in the current velocity ought not to have taken place until the meltwater reached the open channel, and, therefore, deposition of the glaciofluvial sedi-

ments is more likely here than in the tunnel. The reduction in the current velocity at the tunnel mouth also makes it probable that the sediments were transported only a short distance in the open channel.

The stratified drift making up the hummocks may have accumulated on the surface of non-disintegrated glacier ice and obtained its morphology by later disintegration of the ice. The accumulation may also have taken place in connection with disintegrating or already disintegrated glacier ice. In this case, supraglacial and englacial sedimentation, along with sedimentation directly on till or bedrock between bodies of ice, explain the hummocky morphology of the stratified drift.

The accumulation of the stratified drift constituting the hummocks took place later in the northeastern part than in the southwestern part of subarea 1A, which follows from the discussion below. If the stratified drift in subarea 1A accumulated simultaneously on the surface of glacier ice that was not disintegrated, the ice surface must have sloped toward the southwest, i.e. in the paleocurrent direction. This would mean that the ice surface reached at least 160 m a.s.l. northeast of Ylleröd during the deposition of the stratified drift, since the hummocks southwest of Ylleröd are located at this level. However, this is not possible, as the gently sloping valley sides northeast of Ylleröd cannot have protruded above the surface of the ice sheet and, therefore, have controlled the deposition of the stratified drift here. Consequently, it is unlikely that the stratified drift would have been lowered down into the central and deepest part of the valley after the melting of the ice. Neither is it possible that the sedimentation took place simultaneously in subarea 1A if the glacier ice was disintegrated, as the necessary up-slope flow of meltwater northeast of Ynnarp cannot have taken place then.

The stratified drift in the northern plateau in subarea 1A, where sites 5 and 6 are located, accumulated directly on till or bedrock, as deformed stratification was not observed at sites 5 and 6 and the surface of the plateau is even. Water is likely to have been ponded during the deglaciation in the area where the plateau is situated, as the ice sheet receded toward the northeast (see below), i.e. in a down-slope direction. Ponding of water is also supported by the silt beds at site 6 described by Rydenheim (1973). This makes it probable that the ice sheet calved here and, consequently, that the accumulation of the stratified drift took place directly on till or bedrock. The extent of the plateau shows that the sedimentation of the stratified drift took place in a disintegrated part of the ice sheet. This conclusion also applies to the plateau of site 2. The surface of this plateau lies 10 m above the surface of the plateau where sites 5 and 6 are situated. This means that the plateau of site 2 was formed before the plateau of sites 5 and 6, since up-slope transport of meltwater is not possible in a disintegrated part of the ice sheet. Thus, the ice sheet disintegrated later in the northeastern part than in the southwestern part of subarea 1A.

The recession, the direction of the surface slope and the temperature of the ice sheet

The glaciofluvial sediments were transported by subglacial meltwater streams in a part of the ice sheet that had a sloping surface and, therefore, also was active. However, the

deposition of the stratified drift took place in stagnant glacier ice, which shows that such ice must have existed in front of the active part of the ice sheet. The ice sheet receded by gradual stages toward the northeast, since the deposition of the stratified drift took place by gradual stages in this direction.

According to Shreve (1972), the main drainage direction of subglacial meltwater is parallel to the surface slope of a glacier if the meltwater flow is not diverted by the morphology of the area covered by the ice sheet. The main flow direction of the subglacial meltwater southwest of Ynnarp cannot have been controlled by the irregular morphology and low relief occurring here. Consequently, the surface of the ice sheet sloped toward the southwest when the glaciofluvial sediments were deposited here.

The subglacial meltwater drainage indicates that the ice sheet was mainly at the pressure melting point at the base during the accumulation of the stratified drift in area 1. It may have been at the pressure melting point throughout, since it is likely that meltwater penetrated from the surface to the base of the ice sheet.

5.2 Area 2. The Huaröd area

5.2.1 General description

The northeastern slope of the Linderödsåsen horst is 75–100 m high (Fig. 10). Immediately southwest of Ö. Sönnarslöv, the slope is dissected by a 50 m deep and northeast-southwest trending valley that becomes shallower toward the southwest. On the top surface of the horst, the valley is indistinctly delineated from the surroundings, about 10 m deep, and turns to the west about 1.5 km north-northeast of Huaröd. Shallow northeast-southwest trending depressions occur north of this valley. The top surface of the horst, which slopes toward the east, is otherwise irregularly undulating and the relative relief is less than 15 m. The area northeast of the slope of the horst is gently undulating and dissected by some brooks. The relative relief is less than 15 m here.

Cretaceous limy sandstone, sandy limestone and limestone make up the bedrock in the northeastern sand-covered part of area 2. The boundary between these kinds of rocks and the gneiss and the gneissic granite that comprise the horst coincide with the 50 m contour line. The bedrock is mainly exposed along the valley southwest of Ö. Sönnarslöv and along the brooks in the northeastern part of area 2. A quarry occurs in the Cretaceous bedrock 2 km north-northwest of Ö. Sönnarslöv.

One site with glacial striae in the northwestern part of area 2 indicates an ice movement from the north-northeast.

Sandy till dominates the glacial deposits on the horst and well bore logs show that it is about 5 m thick. Hummocky moraine occurs in the area north of Huaröd. The hummocks are about 5 m high and 50–100 m in diameter. Well bore logs indicate that the sand in the northeastern part of the area is underlain by sandy and clayey till that is about 5 m thick.

The glaciofluvial deposits on the horst are mainly found in an northeast-southwest trending zone located in the prolongation of the valley southwest of Ö. Sönnarslöv described above. In the north, the deposits follow the valley and continue toward the southwest where the valley turns to the west. I have remapped these deposits and they are de-

scribed at length in Chapter 5.5.2.

The glaciofluvial deposits found on the slope of the horst 4 km east-northeast of Huaröd are located in a shallow depression.

Bedrock exposures and well bore logs show that the sand northeast of the slope of the horst is less than 10 m thick. The sand is overlaid by varved clay southeast of Ö. Sönnarslöv.

5.2.2 Subarea 2A. Description

The description below of the glaciofluvial deposits in subarea 2A refers to Plate 3.

The two hummocks situated immediately east of Rotsberg are 60 m in diameter and 4 m high.

The ridge 500 m northeast of Rotsberg is 250 m long, 25–75 m wide and 2–4 m high. To the northeast is a ridge that is 350 m long, 2–4 m high and 15–20 m wide. East of this ridge is another ridge which is 60 m long, 20 m wide and 4 m high.

Hummocks, a mound and a plateau make up the morphological elements of the extended deposits of stratified drift northwest of Huaröd. The hummocks are 20–50 m in diameter and 2–5 m high. The mound, which is located 800 m west-northwest of Huaröd, is 200 m long, 100 m wide and 10 m high. The plateau is about 150 m in diameter, 5 m high and is situated 800 m northwest of Huaröd.

The ridges in the area north-northeast of Huaröd are continuous for distances between 300 and 900 m. They are 30–60 m wide and 5–10 m high. The individual ridges vary in height to some extent and an increase in height corresponds to an increase in width. The double ridges are separated by 3–5 m deep, elongated hollows.

Road-cuts and pits show that mainly stony gravelly sand make up the stratified drift in subarea 2A. The pit-walls were covered by scree, except in one sand-pit, named site 9 which is described in the following section.

5.2.3 Exposures

The location of the sites is shown in Fig. 10. Sites 8 and 9 are also indicated in Plate 3.

Sites 8–11

Site 8 – A road-cut in till mainly covered by scree. A sandy and poorly-sorted material with a moderate boulder and stone content is found in the pit. (Appendix 1: G2, Appendix 2: L4). Boulders and stones are angular.

Site 9 – A 3x3 m large and 2 m deep sand-pit, displaying horizontal beds of gravelly sand.

Site 10 – A 50x50 m large and 5 m deep sand-pit with horizontal beds of medium sand and silty fine sand. Ripple lamination in the silty fine sand (xy plane: type B, yz plane: parallel lamination) indicates a paleocurrent from about 300°.

Site 11 – A 40x40 m large and 3 m deep till-pit. The pit-walls are largely covered by scree. The till is sandy, poorly sorted and the boulder and stone content is moderate. Field examination revealed that sizes larger than 11 mm consisted almost entirely of fragments of the gneiss and gneissic granite that make up the Linderödsåsen horst. These kinds



Fig. 10. Area 2, the Huaröd area. Geology and morphology. The contour interval is 5 m. Subarea 2A is indicated.

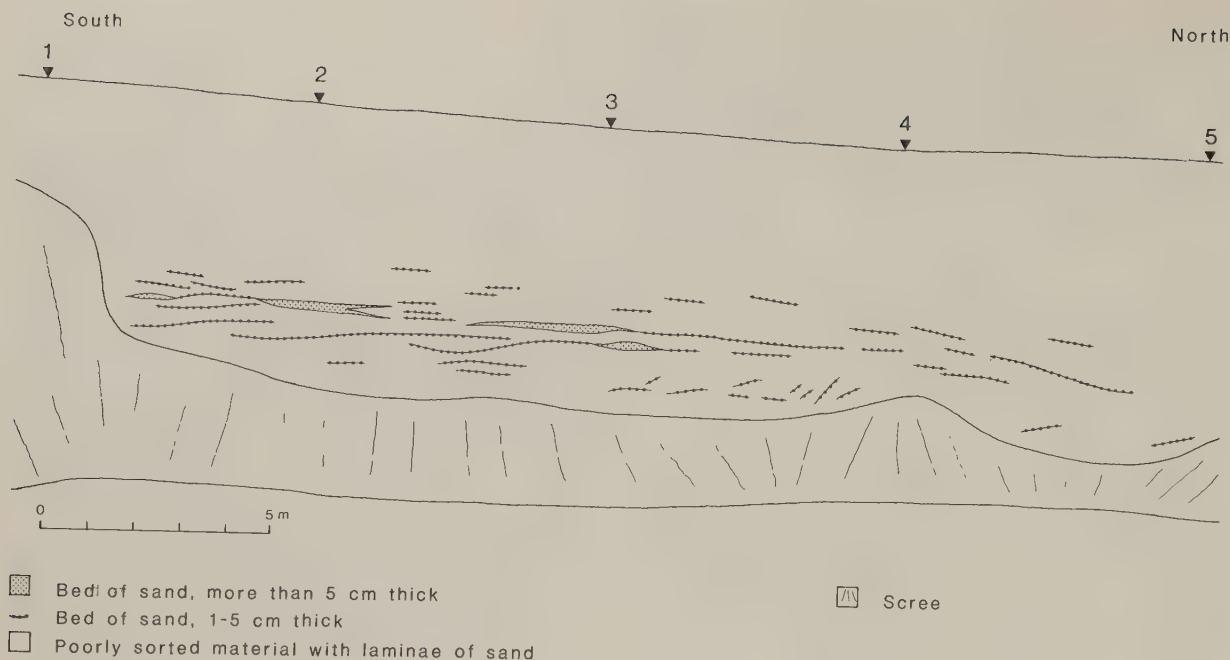


Fig. 11. Section 1-5 at site 12. Site 12 is a till-pit, situated 1 km west-southwest of Ö. Sönnarslöv in area 2 (Fig. 10). The section is orientated at 0-180° and faces the east.

of rocks also predominate in sizes less than 11 mm (Appendix 2: L5).

Site 12

Description - Site 12 a 150x70 m large and 6 m deep till-pit. The ground surface around the pit is smooth and slopes toward the north. Two sections, orientated perpendicular to each other and named section 1-5 and section 6-8 respectively, were investigated in the western part of the till-pit. Section 1-5 (Fig. 11), which is 25 m long and 8 m high, is orientated at 0-180° and faces the east. Section 6-8 is 12 m long and 7 m high. It is orientated at 80-260° and faces the north.

A poorly-sorted material with beds of sand constitutes the till in the western part of the pit (Fig. 11).

The poorly-sorted material is sandy and the stone content is high. Fig. 12 demonstrates the size distribution for grains less than 100 mm and less than 20 mm (Appendix 1: G3). The boulder content is moderate to high and boulders are especially frequent in the lower parts of the sections. Boulders, stones and gravel are angular and consist of the same type of gneiss and gneissic granite that makes up the Linderödsåsen horst. The lithological composition for sizes larger than 11 mm was estimated in the field, whereas the composition for sizes less than 11 mm was determined in the laboratory (Appendix 2: L6).

The beds of sand are 0.1-6 m long, 1-30 cm thick and sub-horizontal, except in the lower part of section 3-5 (Fig. 11). The sand is distinctly laminated. The laminae are mainly parallel to the elongation of the beds and the thinnest laminae are only some millimeters thick.

Discussion - The poorly-sorted material at site 12 was transported by the ice sheet and melted out at its base (Fig. 13). Meltwater

flowed at the boundary between the ice sheet and already accumulated, poorly-sorted material, eroded it and deposited beds of sand. The accumulation of the drift took place gradually upward. This model of deposition follows from the discussion below.

The sand was deposited by meltwater. This is indicated by the distinct lamination which excludes the possibility that the beds of sand were transported by the ice sheet and melted out from its base (cf. Lawson 1979).

There are two reasons why the poorly-sorted material in the pit was not deposited by mass movement. The first reason is that sizes less than 100 mm are predominated by stones, which suggests that the material is too coarse to be a flow till. It is not possible that the material originally was more fine grained and after the deposition became coarse by the action of running water, es-

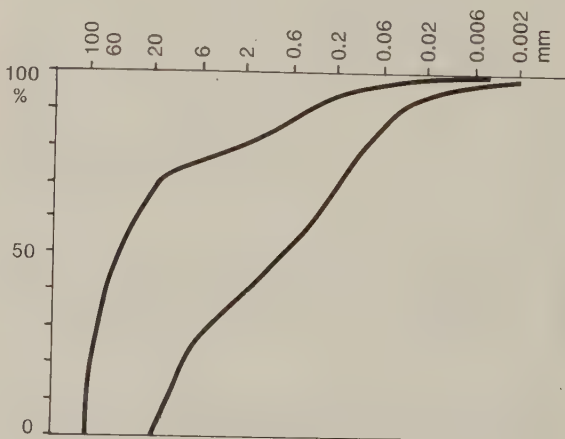
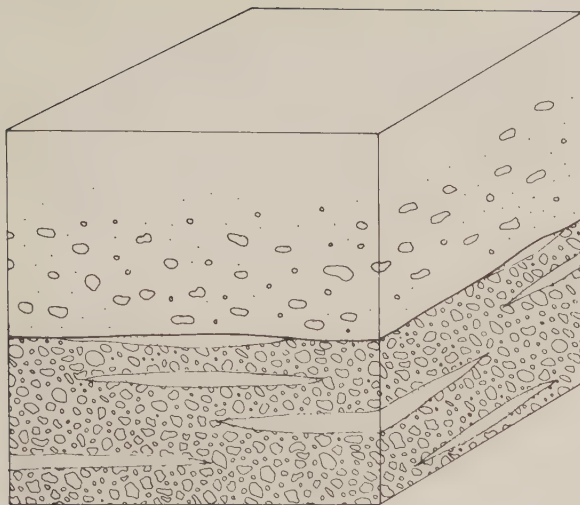


Fig. 12. Grain-size composition of the poorly-sorted material at site 12 for sizes less than 100 mm and 20 mm respectively.



- Glacier ice with debris
 Poorly sorted material Bed of sand

Fig. 13. A model for the deposition of the till at site 12. Sand was deposited by meltwater flowing at the base of the ice sheet and poorly-sorted material accumulated by melt-out of debris carried in the ice sheet. The accumulation took place by gradual stages in an upward direction.

pecially since the material is poorly sorted and silt and sand are mixed with the coarser material. Further, the grain-size composition of the poorly-sorted material is similar in vertical sections. If one or several flowtill beds, sorted by running water, constituted this material, grain size differences ought to occur, as it is not likely that a single and 6 m thick flowtill bed or several thinner beds would have been sorted by running water throughout. The second reason is that the beds of sand are found here and there in the poorly-sorted material. Beds of poorly-sorted material alternating with long and continuous beds of stratified drift, a situation which would be expected if flowtills accumulated in a fluvial or lacustrine environment, are not to be found.

The poorly-sorted material could not have avalanched down a steeply sloping ice surface, as the strata of sand are sub-horizontal and their lamination is well preserved.

Since the poorly-sorted material was not deposited by mass movement, it must have melted out directly from the ice sheet, either at its surface or at its base. However, it is not possible that it is a surface melt-out till, since the beds of sand cannot have been formed at the boundary between already melted-out till and underlying glacier ice. The melted-out till cannot have been frozen, as meltwater must have flowed at the boundary between the till and the underlying glacier ice. Thin and short laminae of sand may have resulted from sedimentation of sand in the small cavities that might have existed at this boundary. However, the beds of sand indicate that cavities up to 0.1 m high and 6 m long occurred here. This is not possible, since cavities of this size would have been filled by the unfrozen till. For the same reason, the beds of sand cannot have originated from sedimentation of sand in cavities formed by melting of ice lenses incorporated

in surface or basal melt-out till.

Cavities may form at the boundary between a glacier and the underlying till if meltwater occurs here and the hydrostatic pressure is high enough to counteract the filling-in force of the till. Thus, the sand at site 12 was deposited by meltwater flowing at the base of the ice sheet and the poorly-sorted material by basal melt-out of englacially transported debris. The height of the cavities in which the sand accumulated may have been less than the thickness of the sand beds. A some millimeter-thick gap between already accumulated sand and the base of the ice sheet would have been enough to allow for the formation of the individual laminae making up the sand beds.

It is not possible to judge whether the ice sheet was stagnant or active during the deposition of the till. The somewhat deformed lamination in the sand beds may have resulted either from loading or from the drag of an active ice sheet.

5.2.4 Discussion

The sediments making up the glaciofluvial deposits in subarea 2A were transported by meltwater flowing along the base of the ice sheet, as the valley southwest of Ö. Sönnarslöv had an influence on the drainage of the ice sheet. This influence is evident from the fact that the only large glaciofluvial deposit on the top surface of the horst is located in the prolongation of this valley, which is the only large incision in the slope of the horst. I have assumed that the ice sheet was drained toward the southwest, since this was the case in area 1.

For two reasons, several glaciofluvial deposits would have occurred in area 2 if the glaciofluvial sediments were deposited by supraglacial meltwater. Firstly, no parts of area 2 can have protruded above the surface of the ice sheet and controlled the large number of meltwater streams that ought to have occurred here. Secondly, the surface slope of the horst and the irregular morphology in area 2 exclude the possibility that supraglacial drift accumulated only in one zone on the horst by meltwater streams flowing in stagnant glacier ice in front of the active part of the ice sheet or proglacially.

The sediments making up the ridges in subarea 2A accumulated directly on till or bedrock, since the transport took place by meltwater flowing at the base of the ice sheet. The morphology of the ridges does not show any signs of disturbance by active glacier ice, which indicates that they were formed in stagnant ice. The mound and the plateau northwest of Huaröd were probably formed in connection with glacier ice that was disintegrating. The stratified drift with hummocky relief was underlain by glacier ice during the accumulation.

The subglacial meltwater which deposited the glaciofluvial sediments flowed in an up-slope direction, which means that the part of the ice sheet in which the transport took place had a sloping surface and, therefore, also was active.

The meltwater conduit indicated by the ridges in the area north and west of Huaröd was parallel to the surface slope of the ice sheet, since the morphology here is irregular and consequently did not influence the main flow direction of the meltwater. This means that the surface of the ice sheet sloped toward the southwest.

From the discussion above, it follows that

the ice sheet was active during the recession in area 2 and, in a north-easterly direction, gradually was transformed into stagnant ice in which the stratified drift accumulated.

Since the glaciofluvial sediments were transported by meltwater flowing along the base of the ice sheet, the ice sheet was mainly at the pressure melting point at least at the base during the recession in area 2.

5.3 Area 3. The Fjällmossen area

5.3.1 General description

Area 3 (Fig. 14) is located on the crest surface of the Linderödsåsen horst (Plate 1). The ground surface is gently undulating and the relative relief is less than 10 m. The western part of the area drains toward the west, whereas the central and eastern parts drain toward the northeast (Fig. 14B). The glacial deposits are predominantly sandy till, which forms hummocks mainly in the area northwest of the peat bog Fjällmossen. A north-east-southwest trending zone with glaciofluvial deposits occurs immediately east of this peat bog. I have remapped these deposits. They are described in the following section.

5.3.2 Subarea 3A. Description

Ridges, hummocks and thin covers of stony gravelly sand constitute the glaciofluvial deposits in subarea 3A (Plate 3). The ridges northeast of site 15 are 50-250 m long, 10-20 m wide and 2-3 m high. The northeastern part of the 450 m long S-shaped ridge southwest of site 15 is situated in the peat bog

Fjällmossen and protrudes less than 1 m above the surface of the peat. The southern part of the ridge is 20-40 m wide and 1-3 m high.

The hummock in which site 14 is located is 75 m in diameter and 4 m high. The rest of the hummocks are 10-20 m wide and 2-3 m high. The thin covers of stratified drift rise less than 1 m above the surrounding till surface and are probably only about 1 m thick.

5.3.3 Exposures

The location of site 13 is marked in Fig. 14A and the location of sites 14-16 is indicated in Plate 3.

Site 13

Description - Site 13 is a 50x30 m large and 1-4 m deep pit. It is located in a mound which is about 200 m in diameter and 5 m high. Boulders protrude above the ground surface of the mound and stony gravelly sand makes up the surface material. The pit is covered with scree except for the section shown in Fig. 15. This section faces the north and is orientated at 80-260°. It is located near the center of the mound where the ground surface is horizontal. Two units, A and B, can be distinguished in this section.

Unit A is at least 2.5 m thick and consists of:

- 1) Sand with diffuse lamination.
- 2) Massive, sandy material which is poorly sorted and has a varying stone and boulder content (Appendix 2: L7).
- 3) Well-sorted gravelly sand and stony gravel-



Fig. 14. Area 3, the Fjällmossen area. A. Geology and morphology. The contour interval is 5 m. Areas above 185 m a.s.l. are shaded. Subarea 3A is indicated. B. The fluvial drainage pattern. The zone with ridges of stratified drift is indicated by a continuous line.

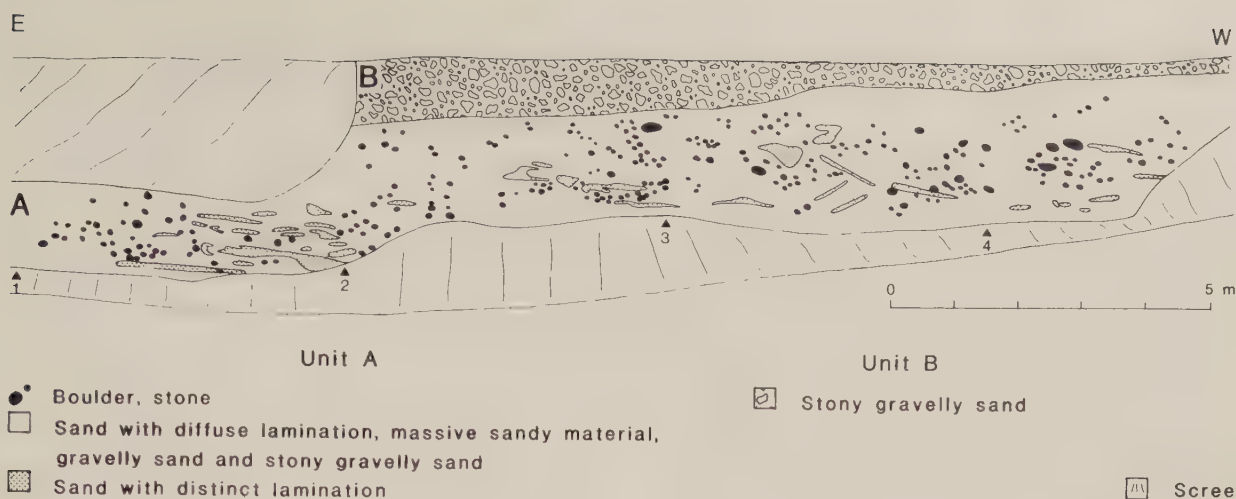


Fig. 15. A section in the pit at site 13, situated immediately north of Bus (Fig. 14). The pit is located in a mound. The section is orientated at 80-260° and faces the north.

ly sand.

4) Beds and irregular bodies of sand with distinct lamination and well-defined boundaries. The laminae consist of silty fine sand, medium sand and coarse sand.

In Fig. 15 only the boundaries of the distinctly laminated sand are marked since the boundaries between the other types of drift are gradual and irregular.

Unit B consists of a 0.2-1.5 m thick bed of stony gravelly sand.

Discussion - The subhorizontal beds of laminated sand are only slightly disturbed, whereas the irregular bodies of sand are greatly disturbed. The occurrence of stratified drift exhibiting varying degrees of disturbance shows that the sedimentation and deformation of the stratified drift were simultaneous. The most likely explanation for this is that silt, sand and gravel were deposited by meltwater flowing at the base of an active ice sheet which disturbed and mixed the stratified drift to a varying degree. Disturbance due to loading is not likely to have caused the mixing, since it is in part intense and in spite of this, the strata of laminated sand are mainly horizontal. Nor it is probable that the slightly disturbed stratified drift was deposited by meltwater currents and the disturbed stratified drift reached its present position by mass movement. This seems logical as the disturbed drift does not form distinct beds separating beds of disturbed material, which ought to have been the case if mass movement alternated with glaciofluvial sedimentation.

Sites 14-16

Site 14 - A 7x3 m large and 2 m deep gravel-pit. Sub-horizontal beds of sand and stony gravelly sand occur here.

Site 15 - A 10x5 m large and 1 m deep gravel-pit displaying stony gravelly sand with diffuse horizontal stratification.

Site 16 - A 20x10 m large and 3 m deep gravel-pit. The pit-walls are largely covered by scree. A 2x2 m large section shows horizontal beds of stony gravelly sand (Appendix 2:

L8) and sand.

5.3.4 Discussion

The meltwater which transported and deposited the sediments constituting the glaciofluvial deposits in subarea 3A originated from an ice sheet with a sloping surface, since the deposits are situated on the crest of the Linderödsåsen horst. It is not possible to judge whether the accumulation took place in glacier ice or directly on till or bedrock. However, the surface of the ice sheet must have sloped toward the southwest (toward 220°) during the deposition of the glaciofluvial sediments, since the morphology in area 3 is irregular and the relative relief is small, which show that the main direction of the meltwater flow was controlled by the surface slope of the ice sheet.

5.4 Area 4. The Viss mosse area

5.4.1 Description

The surface of the Linderödsåsen horst slopes toward the west-southwest in area 4 (Fig. 16A). The crest line of the horst, which trends northwest-southeast, is located immediately northeast of the area. The ground surface is gently undulating and the relative relief is less than 15 m. Shallow and indistinctly-delimited depressions occur between the heights in area 4. The trend of the depressions is indicated by the fluvial drainage pattern shown in Fig. 16B.

The gneiss bedrock is exposed west of the peat bog Viss mosse and the glacial striae occurring here indicate an ice movement from the northeast.

The glacial deposits are predominated by sandy till which is less than 10 m thick.

The glaciofluvial deposits are restricted to a northeast-southwest trending zone in the central part of area 4. They mainly form ridges which trend northeast-southwest. The deposits southeast of Viss mosse are located in a northeast-southwest trending depression which is less than 10 m deep and continue toward the northeast in the area northeast of

10 m deep valley that widens toward the south. Some of the glaciofluvial deposits in this zone are located on heights and some in depressions between heights. The southeastern zone is located in the prolongation of a 25 m deep valley. The southern part of the zone trends mainly perpendicular to the fluvial drainage direction (Fig. 15C) and the glaciofluvial deposits are located in depressions between mounds (Fig. 15D).

I have remapped the glaciofluvial deposits in area 5. They are described in the next two sections.

5.5.2 Subarea 5A. Description

The ridges have a triangular cross-section and are 50-350 m long, 10-30 m wide and 2-4 m high (Plate 3). The individual ridges vary only a little in height and width, apart from a 100 m long section west of site 19 which consists of merging hummocks. Less than 10 m wide and 1 m high banks of stony gravelly sand occur in the gaps between some of the ridges south of the one where site 20 is located.

Mainly stony gravelly sand was observed in the exposures in the ridges. The largest exposures are described in Chapter 5.5.4.

5.5.3 Subarea B. Description

The ridges are 40-650 m long, 10-30 m wide and 2-5 m high (Plate 3). Ridges which are 2-3 m high often have arched-shaped cross-sections, whereas higher ridges have triangular cross-sections. The individual ridges often vary in width and height. Since the ridges often only are a couple of meters high, ridges may be found beneath the peat in the large peat-bog in the southern part of the subarea.

Mainly stony gravelly sand was observed in the exposures in the ridges. One exposure is described in Chapter 5.5.4.

5.5.4 Exposures

The location of the sites is marked in Plate 3.

Site 17 - A 130x30 m large and 2 m deep gravel-pit. The ridge here is removed down

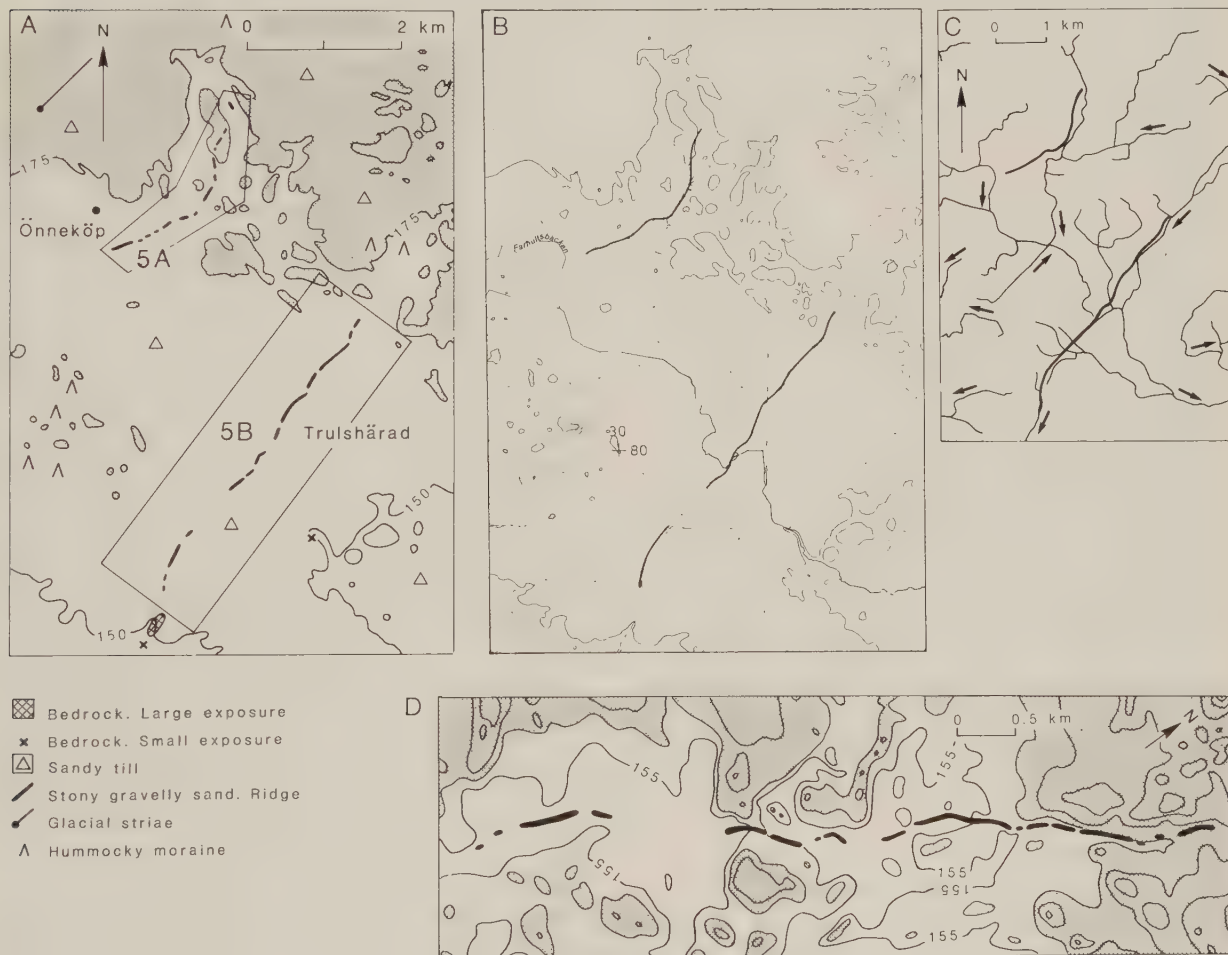


Fig. 17. Area 5, the Önneköp area. A. Geology and morphology. The contour interval is 25 m and areas above 175 m a.s.l. are shaded. Subareas 5A and 5B are indicated. B. Morphology. The contour interval is 5 m. The zones with ridges of stratified drift are shown by continuous lines. C. The fluvial drainage pattern. The zones with ridges of stratified drift are indicated by continuous lines. D. The relation between the morphology of the landscape and the zone with ridges of stratified in subarea 5B. Areas above 160 m a.s.l. are shaded.

to 2 m below the ground surface. The pit-walls are covered by sandy gravelly scree apart from a fresh cut in the southwestern part of the pit. Here, beds of sand with flat lamination alternate with beds of stony gravelly sand (Appendix 2: L9).

Site 18 - A 180x30 m large gravel-pit, the bottom of which is at the same level as the surrounding ground surface. The ridge here is almost completely removed and the remaining parts of the ridge consist of stony gravelly sand.

Site 19 - A 20 m long and 1.5 m high road-cut in till. The till consists of poorly-sorted material with lenses of sand. The poorly-sorted material is sandy and the stone content is moderate. The sand beds are unclearly delimited from the poorly-sorted material and along with variations in the stone and gravel content in the poorly-sorted material form a diffuse horizontal bedding.

Site 20 - A 70x20 m large and 4 m deep gravel-pit, located in a ridge that is mainly removed. The pit-walls display horizontal beds of stony gravel, stony gravelly sand (Appendix 2: L10) and sand. Flat lamination occurs in medium and coarse sand. Ripple lamination in fine sand indicates a paleocurrent from the northwest.

Site 21 - A 20x60 m large and 3 m deep gravel-pit. The pit-walls are largely covered by scree but cleaned surfaces displayed stony gravelly sand with a diffuse horizontal bedding.

5.5.5 Discussion

The zones with glaciofluvial deposits in area 5 are located in the prolongations of less than 25 m deep valleys and the zone in subarea 5B is situated between less than 15 m high mounds. This and the fact that the ground surface slopes toward the northeast along parts of the zones indicate that the sediments making up the deposits were transported by meltwater flowing along the base of the ice sheet (cf. Chapters 5.1.4 and 5.2.4).

Since the subglacial meltwater flowed in an up-slope direction in parts of subareas 5A and 5B, the part of the ice sheet in which the transportation took place had a sloping surface. The trend of the zones with glaciofluvial deposits, which indicate the main flow direction of the subglacial meltwater, shows that the ice surface sloped toward the southwest during the recession of the ice sheet in area 5. The occurrence of subglacial meltwater indicates that the ice sheet was mainly at the pressure melting point at least at the base.

5.6 Area 6. The Hörröd area

5.6.1 General description

The top surface of the Linderödsåsen horst in area 6 (Fig. 18) slopes toward the east-northeast north of Agusa (subarea 6A) and toward the south-southwest south of Agusa. A roughly northeast-southwest trending valley occurs in the central part of area 6. At the mouth south of Degeberga, the difference in height is about 100 m between the top surface of the horst and the bedrock surface below the

valley bottom. The valley becomes shallower toward the southwest. It is around and southwest of Hörröd 15-25 m deep. The valley bottom is located at about 135 m a.s.l. at Agusa and slopes from here toward the northeast and the south-southwest. Irregular heights of varying size and shallow intervening depressions occur in the surroundings of the valley and the relative relief here is less than 15 m. The ground surface northeast of the horst is even and slopes gently toward the northeast.

The boundary between the Cretaceous limy sandstone, sandy limestone and limestone northeast of the horst and the gneiss which makes up the horst coincides with a straight line trending parallel to the 50 m contour line northwest and southeast of Degeberga. The bedrock is mainly exposed in the areas west of Hörröd and south of Degeberga.

The till on the horst is sandy, less than 10 m thick and forms mainly a cover that reflects the irregularities in the underlying bedrock surface. Hummocks of till are common in the area west and northwest of Hörröd. They are 50-100 m in diameter and about 5 m high. Sandy till and clayey till or clay till occur below the sand northeast of the horst. Two excavations were made in the till (Fig. 18: sites 26 and 27). They are described in Chapter 5.10.4.

The glaciofluvial deposits on the horst are located in the above-described northeast-southwest trending valley occurring south-southwest of Degeberga. Stony gravelly sand, forming ridges and hummocky extended deposits constitutes the glaciofluvial deposits southwest of Hörröd. Sand predominates in the valley between Hörröd and Degeberga. Between the northern part of subarea 6D and Degeberga the sand is dissected by northeastward-flowing brooks (Fig. 18A). The glaciofluvial sand northeast of the horst is up to 70 m thick and is in some places overlaid by varved clay.

5.6.2 Subareas 6A-6D. Description

I have remapped subareas 6A-6D. The remapped area is shown in Plate 4. The description below refers to this plate.

The extended deposits of stony gravelly sand form a 0.5-1.7 km wide zone in the central part of the valley. The width of the zone is dependent on the morphology of the valley. The zone is wide where the valley sides are gently sloping and narrow where they are more steep. Hummocks, mounds, irregular and short ridges and gently undulating surfaces constitute the morphological elements of the extended deposits. The hummocks are 30-100 m in diameter and 3-5 m high. Since hummocks lying closely together are common, the Δ -sign in Plate 4 often denotes more than one hummock. The mounds are 100-200 m in diameter, 5-15 m high and are rather often composed of several coalescing hummocks. The irregular ridges are 150-450 m long, 75-200 m wide and 5-10 m high. They are of varying orientation and may consist of a row of mounds lying in contact with each other. The gently undulating surfaces may be almost even, but may also be gently hummocky with a relative relief that is less than 2 m.

Regular and well-defined ridges of stony gravelly sand mainly trending parallel to the long axis of the valley occur in the central part of the zone with extended deposits. The ridges have triangular cross-sections (Fig. 21A) and are aligned in a single row except



Fig. 18. Area 6, the Hörröd area. A. The fluvial drainage pattern. B. Geology and morphology. The contour interval is 25 m. Subareas 6A-6E are indicated.

for in subarea 6B. The ridges are 300-600 m long and south of Snärpe in subarea 6A and in subareas 6C and 6D separated from each other by gaps. North of Snärpe in subarea 6A and in subarea 6B, they lie in contact with each other and form a continuous and

winding zone that is 3 km long. The eastern zone of ridges in subarea 6B is 1 km long. The ridges have triangular cross-sections, are 40-70 m wide and 5-15 m high. They are mainly distinctly delimited from the surrounding extended deposits. However, the ridges merge

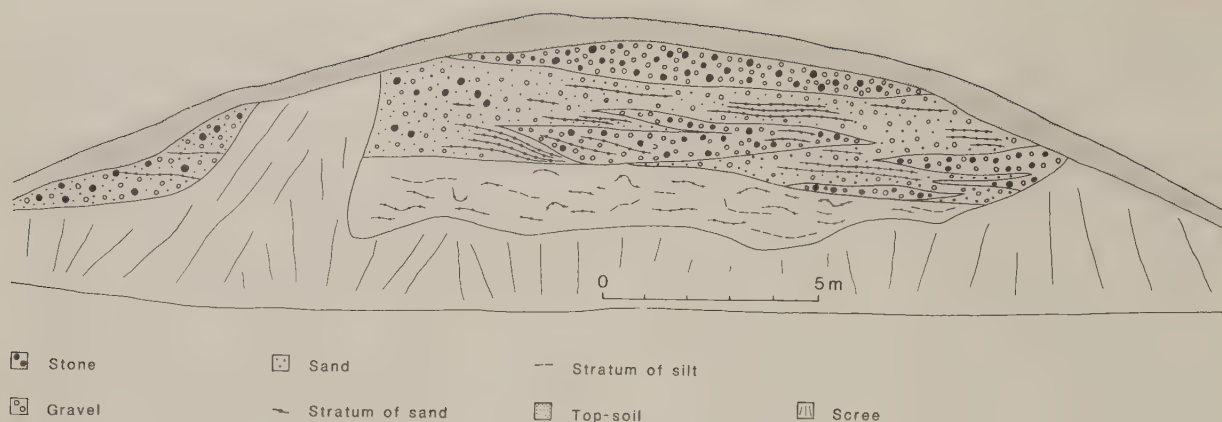


Fig. 19. A section in a mound at site 23 in subarea 6A (Plate 4). The section is orientated at 90-270° and faces the north.

into extended deposits 0.5 km south-southwest of Snärpe, 1 km east-northeast of Agusa, immediately southwest of the boundary between subarea 6B and 6C and 1 km west-southwest of Hörröd.

The glaciofluvial deposits predominated by sand in subarea 6D occur in a 0.6-1.2 km wide zone on the bottom of the valley. The deposits are thickest north-northeast of Hörröd where they form a north-northeast - south-southwest trending plateau, in the southern part of which site 25 is located. The plateau is 1.2 km long, 300-500 m wide and its extent is indicated by the 125 m contour line in Plate 4. The surface of the plateau is generally located between 120 and 125 m a.s.l. but reaches between 130 and 135 m a.s.l. in places and is delimited by 5-10 m high and steeply dipping slopes that have a winding course. Closed depressions, hummocks, mounds and undulating surfaces occur in the surroundings of and southeast of the plateau.

Some of the exposures in subareas 6A-6D are described in the following section.

5.6.3 Exposures

The location of the exposures is shown in Plate 4.

Site 22 - A 160x40 m large gravel-pit with up to 10 m high walls, located in a ridge. South of the road that crosses the central part of the pit, the ridge is completely removed while only the northern part of the ridge is removed north of the road. The sections occurring here are 30-40 m long and 5-10 m high. They display beds of stony gravel alternating with beds of sandy gravel (Appendix 2: L11) and some beds of sand also occur. The beds are horizontal, parallel to the long axis of the ridge, and slightly upwardly convex perpendicular to the long axis of the ridge. Boulders, stones are subrounded to rounded (Fig. 21B). Ripple lamination in fine sand (xy plane: type A, yz plane: troughs) indicates a paleocurrent from on an average 20°.

Site 23 - A 35x35 m large gravel-pit located in the northwestern part of an irregular ridge consisting of two coalescing mounds. The surface material is till-like and contains boulders. The pit has only one wall, which

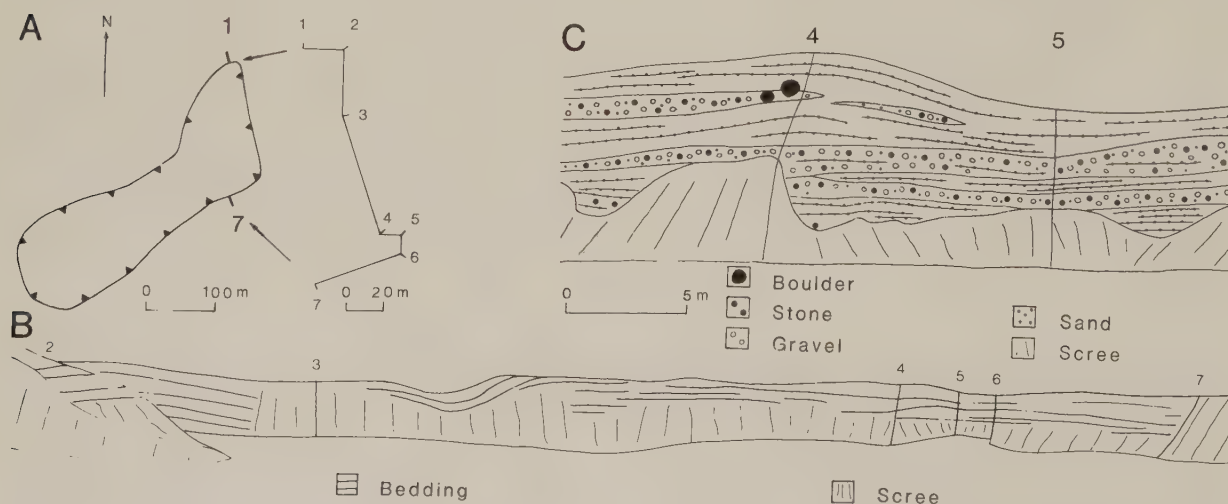


Fig. 20. The sand-pit at site 25 in subarea 6D (Plate 4). A. Map of the pit. B. The bedding in section 1-7. C. Close-up of section 4-6. A part of section 5-6 is covered by Fig. 21C.



Fig. 21. Stratified drift in area 6. A. A ridge of stony gravelly sand with triangular cross-section. The ridge is located east of Snärpe (Plate 4) and the photo B taken toward the east. B. Sub-rounded to rounded stones in stony gravelly sand at site 22 (Plate 4). The rod is divided into 25 cm long intervals. C. Flat lamination and trough cross-lamination in section 5-6 at site 25. (Fig. 20).

is orientated at $90-270^\circ$ and faces the north (Fig. 19). Silty sand is found in the lower part of the pit-wall. Irregular and contorted laminae and thin beds of medium sand, fine sand and silt alternate here. The beds and laminae are mainly horizontally aligned. Horizontal beds of stony gravel and stony gravelly sand (Appendix 2: L12) with thin beds and laminae of sand occur in the upper part of the pit-wall. The boundaries between the beds of stony gravel and stony gravelly sand are to some extent diffuse. Stones are mostly

subangular. Flat lamination occurs in the sand.

Site 24 - A small till-pit, situated in the upper part of a mound. The pit-walls are covered by scree apart from a 2×2 m large surface where sandy, poorly-sorted material with a few boulder and stone content is found. The material is partly massive and partly displays fubar stratification.

Site 25 - A 350×100 m large and 10 m deep

sand-pit (Fig. 20). The walls in the north-eastern part of the pit are fresh. The remaining walls are to a large extent covered by scree, but horizontal bedding is sometimes visible here. Horizontal beds of stony gravelly sand (Fig. 21C) and sand occur in the north-eastern part of the pit. The relationship between stratification and grain size described below occurs here. Internal stratification does not occur in the beds of stony gravelly sand apart from horizontal beds of sand with flat lamination. Trough cross-lamination is common in fine-gravelly sand (Fig. 21C) but is also found in sand. The sets are 5-30 cm thick and the troughs are 30-80 cm wide. Flat lamination predominates in coarse sand (Fig. 21C). Ripple lamination occurs in medium and fine sand. Trough cross-lamination and ripple lamination (xy plane: type A, yz plane: troughs) indicate a paleocurrent from on an average 60°. The upward concave bedding in the northern part of section 3-4 (Fig. 20B) coincides with a trough in the ground surface.

5.6.4 Subareas A-D. Discussion

The drainage of the ice sheet

The location of the glaciofluvial deposits in a less than 25 m deep valley and in the prolongation of the only marked incision in the slope of the horst can be explained if the sediments constituting the glaciofluvial deposits were transported by meltwater flowing along the base of the ice sheet.

Meltwater which flowed on the surface of the ice sheet and the distribution of debris on the ice surface cannot have been controlled by the low relief in area 6. Therefore, if mainly supraglacially flowing meltwater deposited glaciofluvial sediments in area 6, the result would have been several small deposits (Fig. 9B). It is unlikely that supraglacial meltwater streams or meltwater from stagnant and disintegrating glacier ice flowed down into the valley in subareas 6A-6D and deposited stratified drift here, although the fluvial drainage pattern in area 6 (Fig. 18A) makes this theoretically possible. This follows

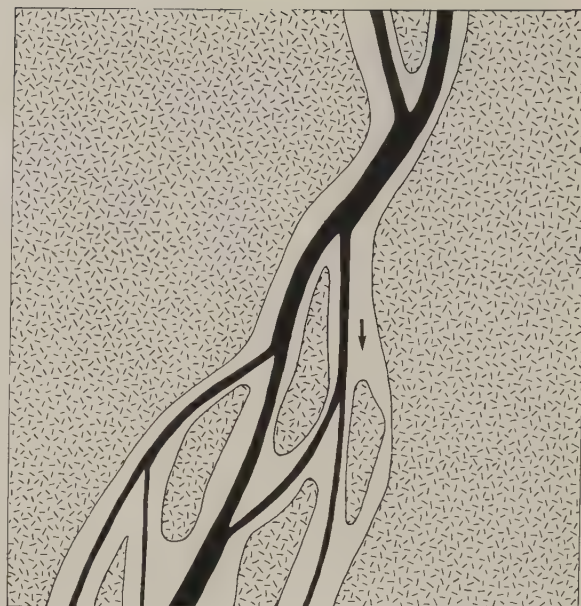


Fig. 23. The topographical influence on the subglacial meltwater drainage in a valley with irregular relief. The meltwater streams are confined to the topographic lows of the valley. Alternating convergent and divergent meltwater flow is caused by protrusions of bedrock or till.

from the discussion below. If the stratified drift in the ridges originated from the area west of the valley, connecting ridges ought to have occurred, because it is not possible that after a comparatively short distance of transport, deposition took place only in a conduit parallel to the valley and not in the feeding conduits. The irregular ridges that are orientated transverse to the valley do not indicate feeding conduits, since they are only sometimes located where depressions lead into the valley. Further, they are perpendicular to the northeast-southwest trending zone with regular ridges. This shows that they do not indicate feeding conduits, as running water is not deflected at right angles. The extended deposits of stratified drift are often thickest in the central part of the valley. This would not have been the case if the stratified drift making them up was delivered from the area west of the valley.

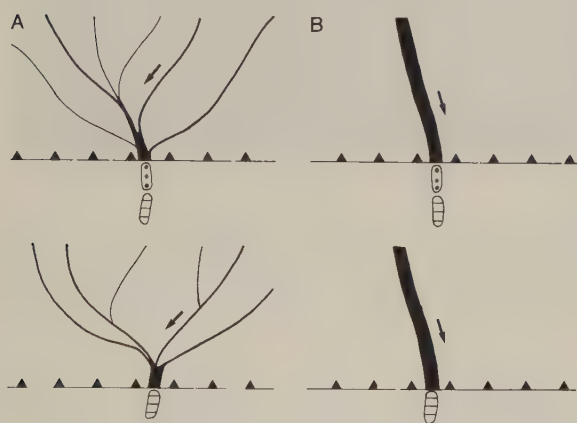


Fig. 22. Two different subglacial drainage patterns at two successive positions of the ice margin. The tunnel mouth has a fixed position, which results in a row of ridges of stratified drift. A. Several meltwater conduits that shift position beneath the ice sheet and converge at the ice margin. B. One conduit with a fixed position beneath ice sheet.

The subglacial drainage pattern

The ridges of stratified drift are mainly aligned in a single row trending parallel to the valley. In subarea 6B parallel and double ridges also occur. If the stratified drift making up the ridges accumulated simultaneously in subareas 6A-6D, the ridges would indicate that one and in part two conduits with well-defined positions existed here. As can be seen in the discussion below, it follows that these conduits were closed. It is likely that the sediments constituting the ridges accumulated directly on till or bedrock, since the transport was by subglacial meltwater streams. Therefore, if the sediments accumulated all at once in an open channel in subareas 6B-6D, the ridges ought to be wider and higher toward the northeast, as the sediment surface in the open channel must

have sloped toward the southwest and the valley floor slopes toward the northeast in subareas 6B-6D. However, the ridges are of similar width and height.

If the formation of the ridges took place at the mouths of the conduits or tunnels by gradual stages toward the northeast during the recession of the ice sheet, the ridges would also indicate tunnels with fixed positions. The tunnel mouths ought to have had fixed positions in a direction transverse to the valley, as otherwise ridges would have occurred here and there in the valley. It is not likely that several small conduits close to the margin of the ice sheet would have converged into one large conduit in which the stratified drift accumulated and formed a ridge (Fig. 22A). Such a convergence would mean that the conduits formed an acute angle with the direction of the surface slope of the ice sheet, which is unlikely. Thus, only one tunnel trending along the valley occurred upstream of a tunnel mouth (Fig. 22B). This tunnel must have had a fixed position, because if it changed position continuously beneath the ice sheet, it is likely that the position of the tunnel mouth also changed in a direction transverse to the valley.

It is likely that the till and bedrock surface in the valley is irregular, since this is the case in the surrounding areas. Thus, depending on the relief in the valley, one or several meltwater conduits are likely to have occurred beneath the ice sheet (Fig. 23). In other words, meltwater conduits can have occurred beneath the ice sheet without leaving ridges.

The recession of the ice sheet and the accumulation of the stratified drift in subarea 6A

The glaciofluvial sediments in subarea 6A

were transported to this area by meltwater flowing in an up-slope direction, which indicates that the part of the ice sheet in which the transportation took place had a sloping surface and, consequently, also was active. The sediments accumulated, however, in connection with stagnant ice, as the morphology of the ridges and the extended deposits of stratified drift does not show any signs of influence from active ice. Therefore, stagnant ice ought to have existed in front of the active part of the ice sheet during the recession of the ice sheet in subarea 6A.

The tunnel indicated by the ridges ought to have been transformed into an open channel when the glacier ice had become so thin that its thickness was the same as the height of the tunnel. It is likely that this transformation took place by gradual stages toward the northeast, since the ice sheet had a sloping surface. A great decrease in the current velocity ought not to have taken place until the meltwater reached the open channel, and, consequently, deposition of stratified drift is more probable here than in the tunnel. The reduction in the current velocity makes it probable that the sediments were transported only a short distance in the open channel. Thus, it is likely that the stratified drift making up the ridges in subarea 6A accumulated where the tunnel was transformed into an open channel. This is supported by the morphology of the ridges between Snärpe and Nybygget (Fig. 24), which is interpreted to indicate the following model of deposition. The stratified drift constituting the wider and higher parts of the ridges accumulated immediately outside the tunnel mouth while the narrower and lower parts accumulated a short distance inside the tunnel mouth. Gaps between the ridges were created as the result of transformation of the tunnel into an open channel at irregular intervals. Glaciofluvial

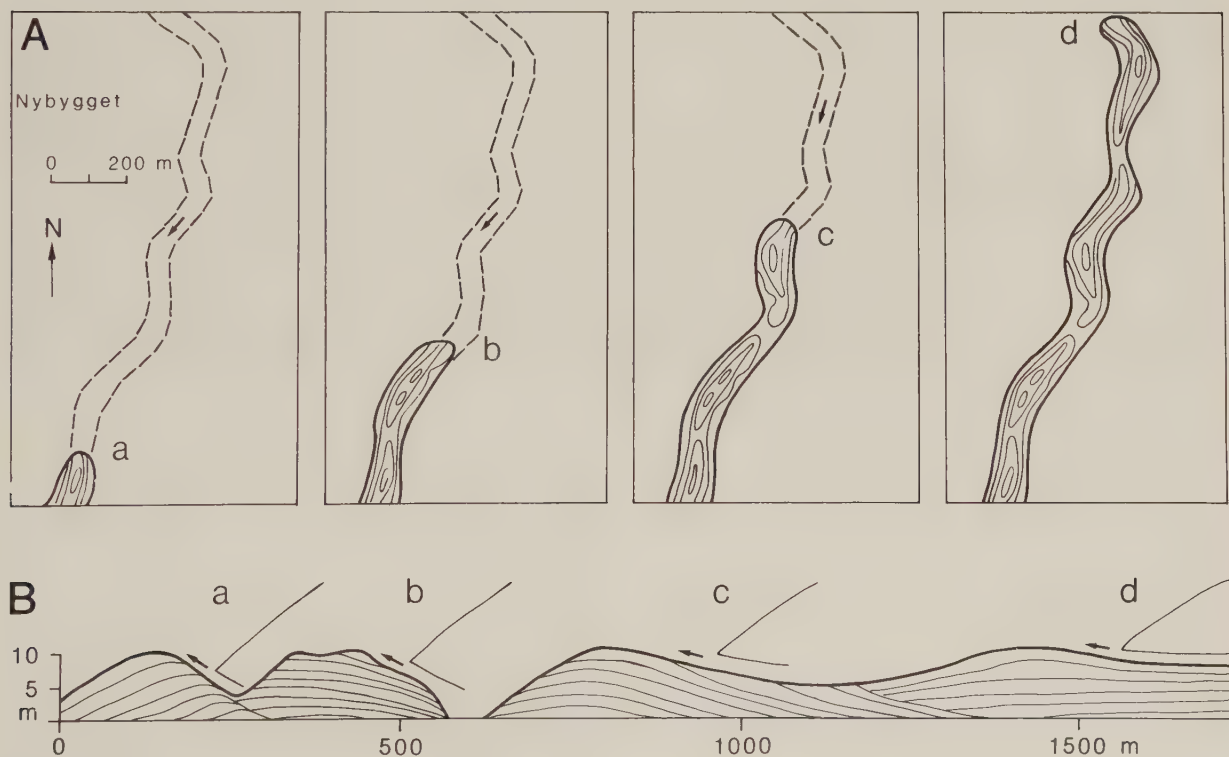


Fig. 24. The formation of the ridges of stratified drift in the area between Snärpe and Nybygget in subarea 6A. A. Seen from above. B. Side view. The bedding of the stratified drift is hypothetical.

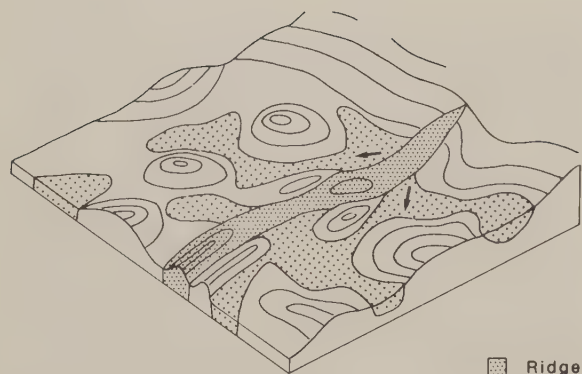


Fig. 25. The formation of the ridges of stratified drift in subarea 6A and accumulation of stratified drift on the ice surface. The sediments making up the ridges accumulated where the tunnel was transformed into an open channel, which took place by gradual stages toward the northeast. Glaciofluvial sediments accumulated on the ice surface when the open channel was filled. The gradual thinning and disintegration of the glacier ice made the ridges protrude above the ice surface and gave the glaciofluvial accumulations underlain by ice a hummocky relief.

sediments ought to have accumulated on the surface of the ice sheet when the open channel was infilled at the tunnel mouth (Fig. 25). It is likely that this material obtained a hummocky relief in connection with the disintegration of the glacier ice.

It is probable that the sediments constituting the extended deposits not only were transported in the conduit indicated by the ridges but also in other conduits. The mounds and the hummocks located north of the large peat bog east of Nybygget suggest this, since they are found in the prolongation of a zone with northeast-southwest trending ridges in subarea 6B. The absence of ridges in the area north of the peat bog shows that the deposition of the stratified drift took place in a disintegrating part of the ice sheet. Disintegrating glacier ice is characterized by sink-holes, caves, open channels, englacial tunnels and subglacial tunnels forming a com-

plicated drainage system (Sharp 1949, Hartshorn 1952, Clayton 1964, Healy 1975). Fig. 26 suggests how the deposition of the glaciofluvial sediments in disintegrated glacier ice took place. The sediments accumulated probably mainly where tunnels were transformed into open channels and were interrupted by sink-holes and caves. When these were filled, sediments may have been spread on the surface of the stagnant glacier ice. New drainage routes are likely to have formed continuously by infilling of conduits and by melting of the glacier ice simultaneously with the sedimentation.

Slow melting of glacier ice and the formation of thermokarst require that drift occurs on the surface of the ice sheet. This requirement ought to have been met in subarea 6A, since hummocks of till, indicating the occurrence of till on the ice surface, occur in area 6.

The recession of the ice sheet and the accumulation of the stratified drift in subareas 6B and 6C

The extent and morphology of the extended deposits of stratified drift in subareas 6B and 6C indicate that they were formed in connection with stagnant and disintegrating glacier ice. Up-slope motion of meltwater is not plausible in such an environment. If the accumulation of the stratified drift was simultaneous in subareas 6B and 6C, the stratified drift in subarea 6C must have been underlain by glacier ice that reached at least the same level as the stratified drift in subarea B, i.e., more than 150 m a.s.l. However, this cannot have been the case, because if the ice was so thick, the valley sides in subarea 6C would not have protruded above the ice surface and have controlled the sedimentation here (Plate 4, Fig. 27B). It is not probable that the accumulation of stratified drift on the ice surface took place only in a restricted zone and that this zone was lowered down into the central part of the valley when the ice melted away. Consequently, the accumulation of stratified drift was later in subarea 6C than in subarea 6B. As the meltwater that delivered the sediments to subarea 6B flowed in an up-slope direction, the ice sheet was not disintegrated and had a sloping surface in subarea 6C during the deposition of the

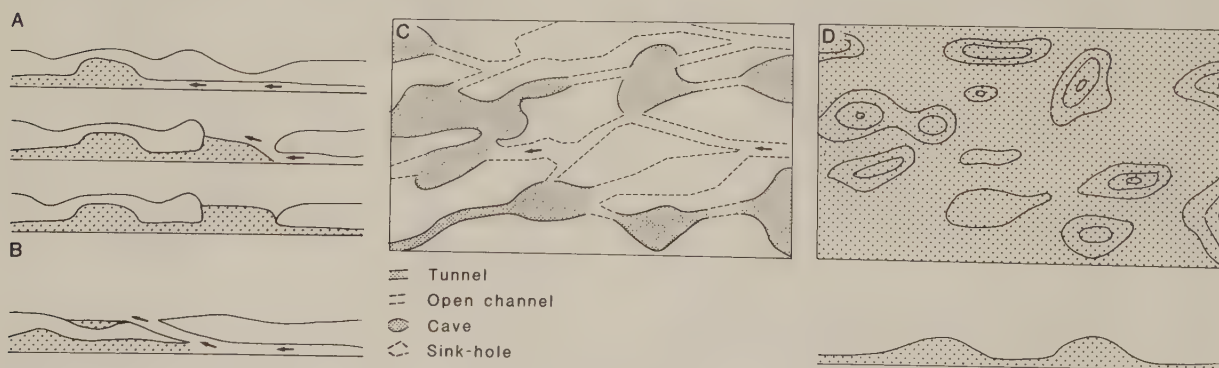


Fig. 26. A model for the formation of mounds and hummocks of stratified drift in stagnant and disintegrating glacier ice fed with glaciofluvial sediments that were transported by subglacially flowing meltwater in the non-disintegrated part of the ice sheet. A. The gradual infilling of sink-holes and caves interrupting a tunnel. B. Transport of sediments to the ice surface due to infilling of a tunnel. C. Disintegrating glacier ice with alternating tunnels, open channels, caves and sink-holes. D. The resulting morphology of the sediments that accumulated in glacier ice according to Fig. 26C.

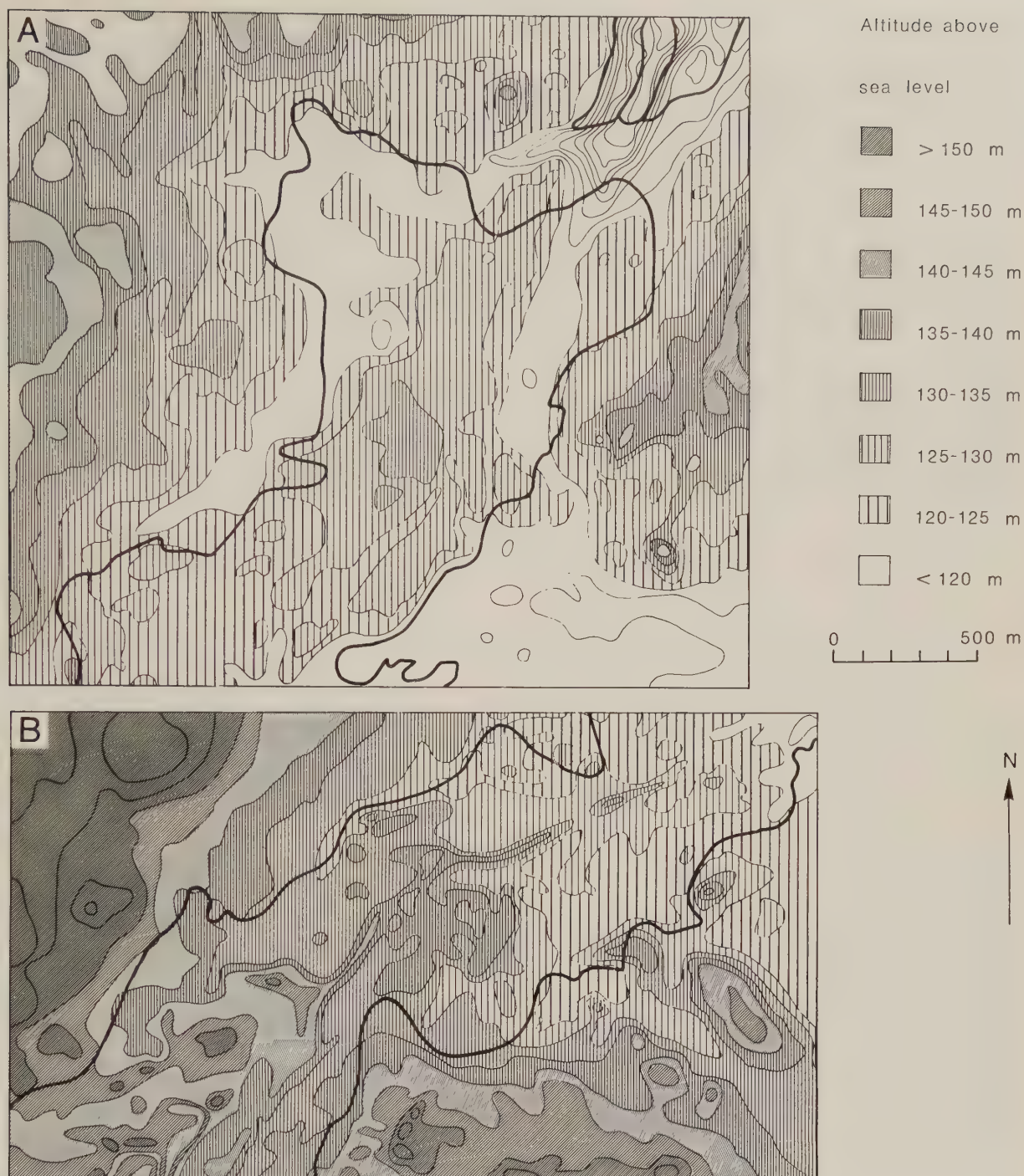


Fig. 27. Contour interval map of subareas 6B-6D. The boundaries between till and stratified drift are indicated. A. The central and northern parts of subarea 6D. B. Subareas 6B, 6C and the southern part of subarea 6D.

sediments in subarea 6B (Fig. 28).

The discussion below of the accumulation of the stratified drift in subareas 6B and 6C and the drainage of the ice sheet refers to Fig. 29 if nothing else is specified. The letters A-I in the text below pertain to this figure. Figure 29 should be compared with Plate 4.

The stratified drift making up the extended deposits between A and B accumulated in branching meltwater conduits, since the deposits are connected with the C-ridge at B and consist of coalescing plateaus and mounds

that form forking and irregular ridges. The morphology of the deposits shows that the formation took place in connection with dis-integrating glacier ice.

The C-ridge was formed in a conduit that probably was connected north of E with the conduit indicated by the G-ridge, because the C-ridge and its continuation in subarea 6A is located in the prolongation of the G- and I-ridges. It is not likely that the C- and G-ridges were formed simultaneously, as in this case accumulation of stratified drift ought to have taken place in the conduit

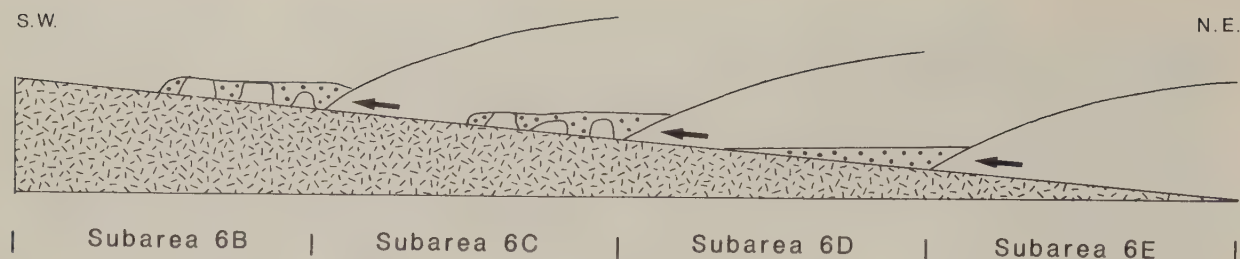


Fig. 28. The gradual disintegration and recession of the ice sheet in subareas 6B-6D. The glaciofluvial sediments accumulated in connection with stagnant and more or less disintegrated glacier ice. The sediments were transported in an active and non-disintegrated part of the ice sheet.

between the C and G-ridges as well. It is, however, possible to explain the gap if the meltwater abandoned the conduit after the formation of the C-ridge and flowed in the conduit indicated by the D-ridge. From this it follows that the G-ridge probably was formed after the C-ridge.

At F, the G-ridge is connected with extended deposits of stratified drift. The extension and morphology of these deposits show that they were formed in a subaerial environment. Consequently, the stratified drift making up the G-ridge accumulated in an open channel (cf. subarea 6A).

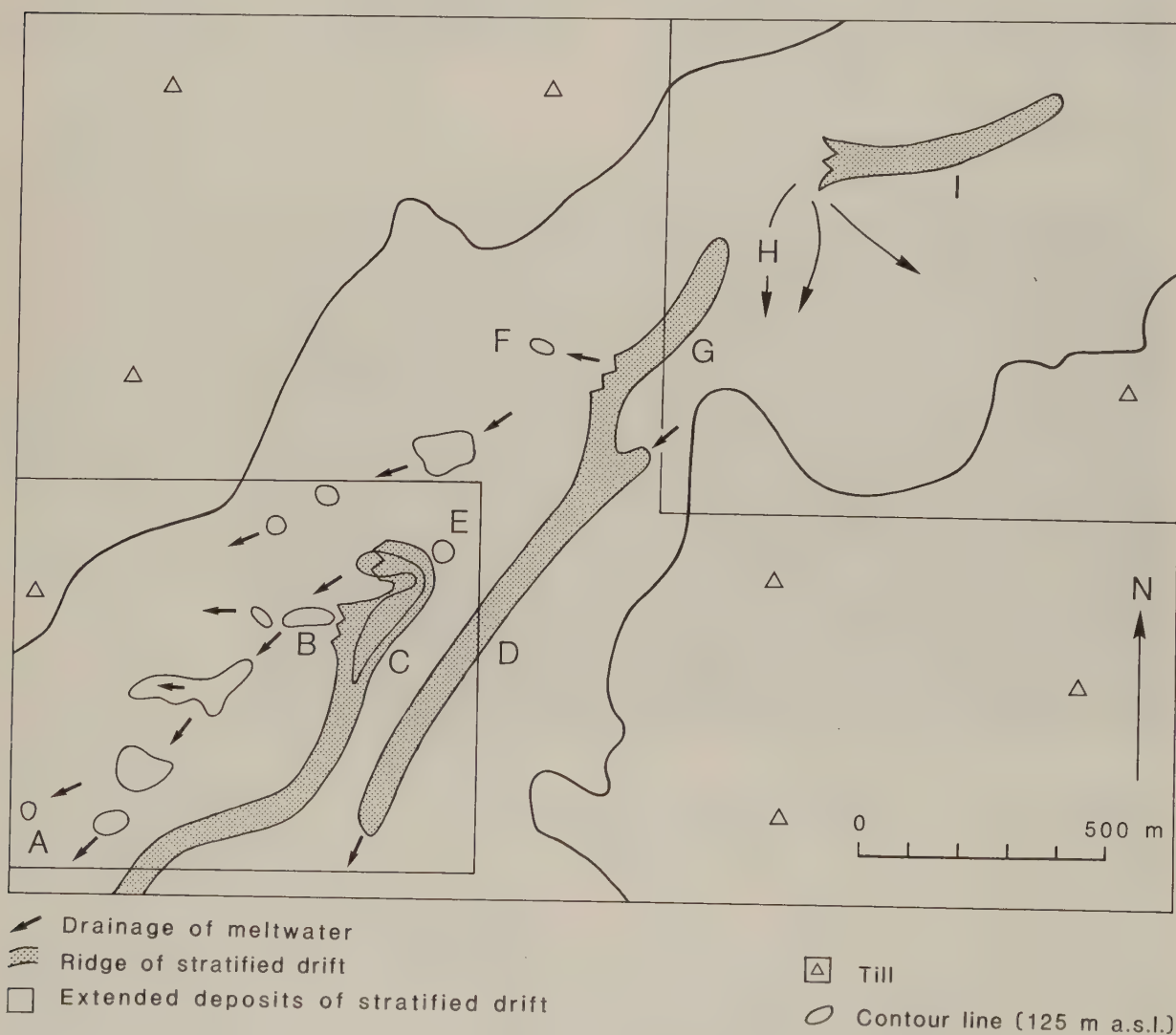


Fig. 29. The drainage of meltwater and the relation between the ridges and the extended deposits of stratified drift in subareas 6B and 6C and the southern part of subarea 6D. The letters A-I pertain to the text. The box to the left is covered by Fig. 30 and the one to the right by Fig. 31.

The I-ridge was formed after the G-ridge, as it is connected with extended deposits of stratified drift at H. The connection also shows that the sediments constituting the I-ridge were deposited in an open channel (cf. subarea 6A).

The part of the ice sheet in which the stratified drift making up the ridges accumulated was stagnant and not disintegrated, since the morphology of the ridges shows no signs of disturbance by active ice and the ridges indicate well-defined meltwater conduits. Therefore, the transition between the

extended deposits and the G-ridge at F indicates a boundary zone southwest of which the ice sheet was disintegrated and northeast of which it was not disintegrated when the ridge and the extended deposits were formed.

The transition between the I-ridge and the extended deposits at H also indicate a boundary zone between disintegrated and non-disintegrated glacier ice. This zone relates, however, to a somewhat later phase of the deglaciation of subareas 6B and 6C.

A model for the accumulation of the stratified drift and the recession of the ice sheet

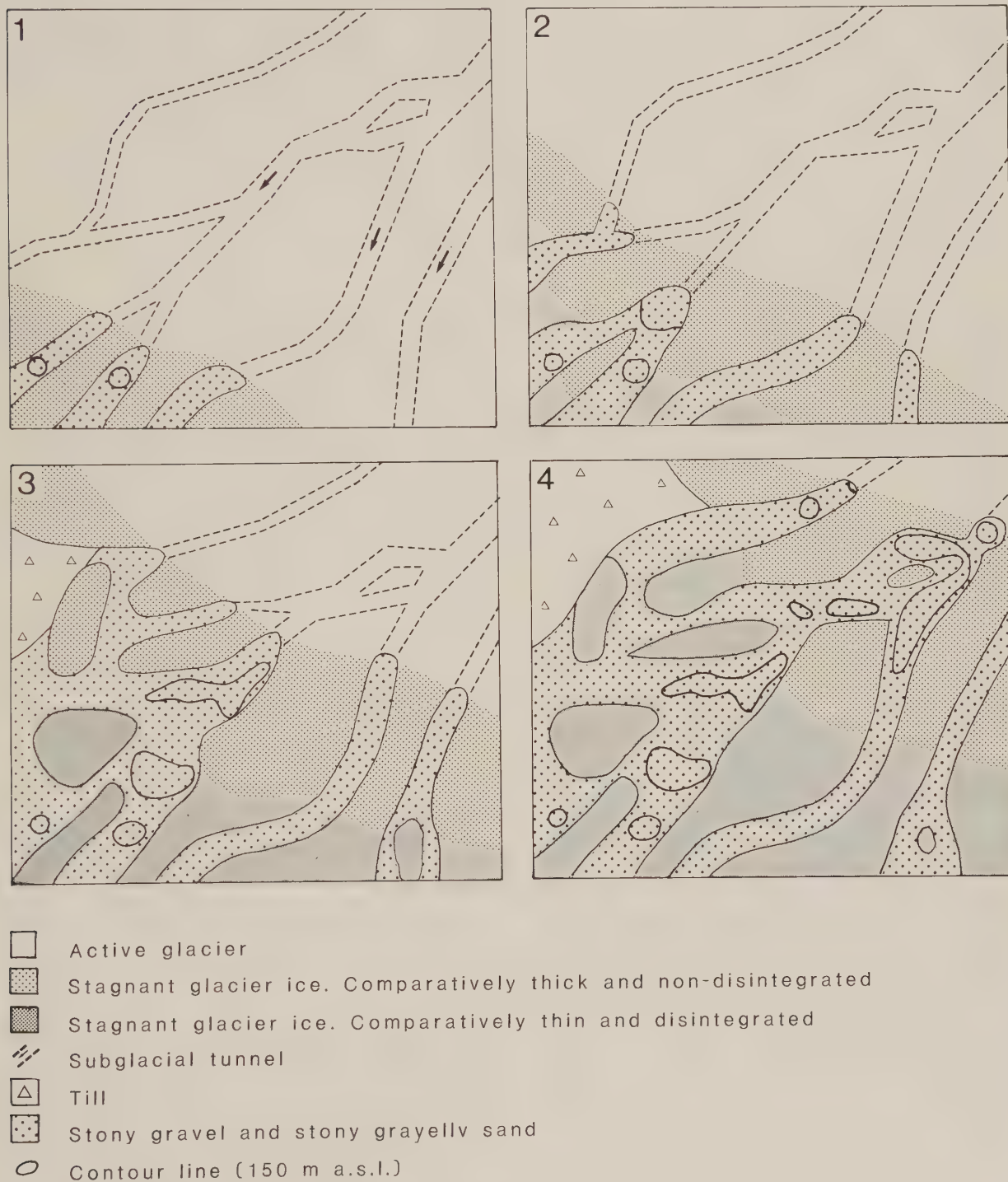


Fig. 30. The gradual disintegration of the ice sheet and the accumulation of stratified drift in a part of subarea 6B. The location of the area is shown in Fig. 29.

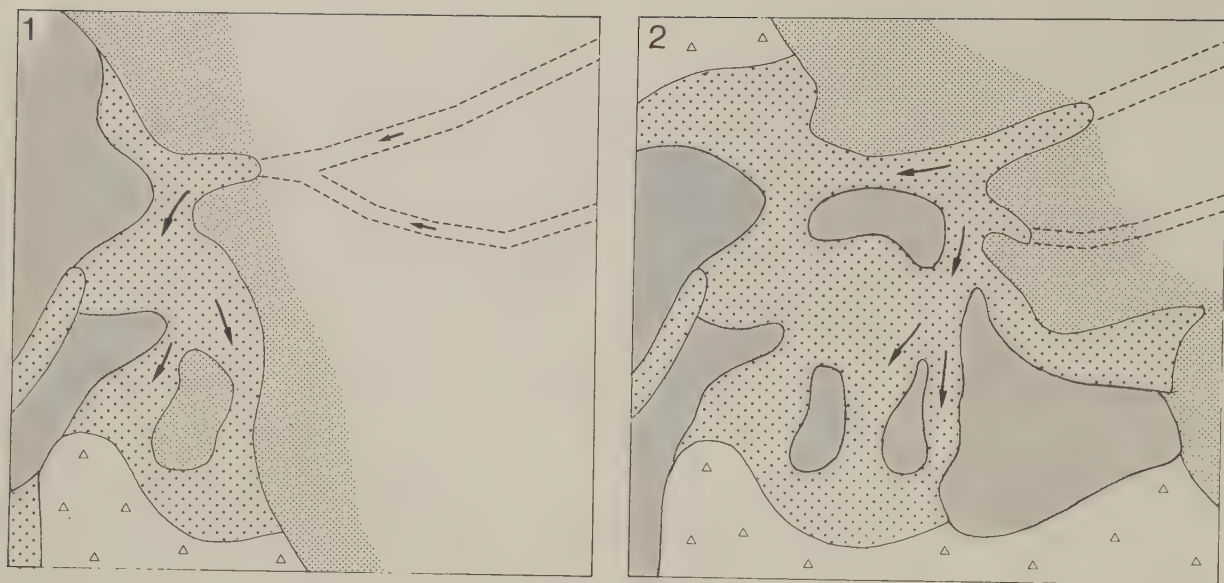


Fig. 31. The gradual disintegration of the ice sheet and the accumulation of stratified drift in a part of subarea 6C. The location of the area is shown in Fig. 29.

in a part of subarea 6B is shown in Fig. 30. The location of the area is shown in Fig. 29. The details in Fig. 30 are hypothetical and the figure is only intended to illustrate the main features in the course of the deglaciation. Drift was transported by meltwater streams flowing in a number of tunnels in the active part of the ice sheet. The deposition of stratified drift took place in stagnant glacier ice in front of the active part of the ice sheet and by gradual stages toward the northeast. Accumulation of stratified drift in non-disintegrated glacier ice resulted in ridges and accumulation in disintegrated ice resulted in extended hummocky deposits.

The plausible course of the deglaciation in a part of subarea 6C is illustrated in Fig. 31. The southwardly deflection of the meltwater was probably caused by the northward sloping valley.

The recession of the ice sheet and the accumulation of the stratified drift in subarea 6D

The mainly sandy glaciofluvial deposits in subarea 6D indicate that a glacier-dammed lake existed here during the recession of the ice sheet. The steep slopes that define the plateau north-northeast of Hörröd (Plate 4, Fig. 27A) ought to have been the result of ice contacts, since their shape and the morphology of the low-lying surrounding areas exclude the possibility that they were formed by fluvial erosion. The ice contacts were probably due to calving of glacier ice in the central part of the valley, whereby a calving bay was formed in which the stratified drift accumulated. The sedimentation, therefore, is likely to have taken place mainly directly on till or bedrock. Also, there is no evidence of disturbances of the stratified drift at site 24, apart from the down-warped beds in section 3-4 (Fig. 20B). The till-covered areas that surround the glaciofluvial deposits in subarea 6D reach everywhere above 130 m a.s.l. apart from east-southeast of Hörröd, where the ground surface is situated between 120 and 125 m a.s.l. and east-northeast of Hörröd where it is situated between 110 and

115 m a.s.l. However, glacier ice may have occurred here and dammed the lake in which the sand accumulated. The ice contacts discussed above show that glacier ice occurred in the area east-northeast of Hörröd during the sedimentation of the sand. Damming is possible even if the damming ice was stagnant, to judge from the ponds and lakes which exist in disintegrated glacier ice in front of present-day glaciers (e.g. Sharp 1949).

As the stratified drift making up the plateau in subarea 6D accumulated directly on till or bedrock, it follows that its surface was 5-10 m below the surface of the glaciofluvial deposits in subarea 6C (Fig. 27A). This means that the stratified drift in subarea 6D was deposited later than the stratified drift in subarea 6C, as up-slope flow of meltwater cannot have taken place in a sub-aerial environment. Further, it is impossible that fine-grained stratified drift accumulates closer to the ice sheet than coarse-grained stratified drift, which would have been the case if the sedimentation had been simultaneous in subareas 6C and 6D. When the stratified drift in subarea 6C accumulated, the ice sheet was not disintegrated and had a sloping surface in subarea 6D (Fig. 28), since the meltwater which carried the drift to subarea 6C moved in an up-slope direction. For the same reason, the ice sheet was not disintegrated and had a sloping surface in subarea 6E (Fig. 18) during the deposition of the stratified drift in subarea 6D. The non-disintegrated part of the ice sheet was active, since it had a sloping surface.

The recession, the direction of the surface slope and the temperature of the ice sheet

The boundaries between active, non-disintegrated glacier ice and stagnant, more or less disintegrated glacier ice established above show that the ice sheet receded by gradual stages in a northeasterly direction.

The ice surface sloped roughly toward the southwest during the recession, since the low relief in subareas 6A-6D ought to have controlled the main flow direction of the subglacial

cial meltwater only to a limited extent.

The subglacial meltwater drainage shows that the ice sheet at least at the base was mainly at the pressure melting point during the recession in subareas 6A-6B.

5.6.5 Subarea 6E. Description

General

The geological map covering subarea 6E (Fig. 32A) and the description below are both based mainly on well bore logs and on the investigations made by G. De Geer (1889a) and Thuning (1980).

Cretaceous limy sandstone, sandy limestone and limestone make up the bedrock northeast of the horst. Figure 33, which is based on well bore logs, shows that the northeast-southwest trending valley in the horst continues in the Cretaceous bedrock northeast of Degeberga, turning here to the east.

The till on the horst is sandy. Sandy till occurs below the sand in the valley south-southwest of Degeberga. Sandy till and clayey till or clay till have been observed below the sand northeast of the horst. In some places, till-like material rests on the sand in the valley south-southwest of Degeberga (Thuning 1980). According to G. De Geer (1889a), the surface of the mound 1 km south-east of Degeberga is covered by till. In actuality, the till is only boulders resting directly on sand (Thuning 1980). Thuning found that on the northeastern side of the mound, boulders were more frequent between 30 and 57 m a.s.l. than above 57 m a.s.l.

Sand dominates the glaciofluvial deposits in subarea 6E. Exposures and auger bore logs show that strata of silt and laminae of clay occur in the sand.

The sand in the valley south-southwest of Degeberga is dissected by brooks. The brooks have carried away large amounts of sand especially from the central part of the valley.

The sand northeast of the horst is 10-70 m thick and is overlaid in some places by varved clay.

The sand in subarea 6E often rests directly on the bedrock (Fig. 32). Sand below till has been observed on the horst (Fig. 32: site 30), in the valley southeast of Degeberga (Fig. 32: well bore log 2) and northeast of the horst (Fig. 32: well bore logs 9 and 17).

Auger bore logs

The auger bore logs presented below are according to Thuning (1980). They are described from the ground surface and downward and their location is noted in Fig. 32A.

Bore 3 - 0-0.6 m: Fine sand. 0.6-1.0 m: Silt. 1.0-2.6 m: Fine sand with silt strata. 2.6-2.8 m: Sand. 2.8-3.2 m: Silt with clay laminae. 3.2-4.1 m: Fine sand with silt strata. 4.1-5.0 m: Sand with silt strata. 5.0-6.9 m: Fine sand with silt strata. 6.9-8.0 m: Clayey fine sand. 8.0-9.2 m: Sand. 9.2-10.2 m: No observations. 10.2-11.0 m: Fine sand with silt strata. 11.0-11.2 m: Silt with clay laminae.

Bore 4 - 0-1.3 m: Sand. 1.3-1.5 m: Silty sand. 1.5-1.7 m: Varved clay. 1.7-3.1 m: Silty sand. 3.1-3.2 m: Clay. 3.2-4.6 m: Sand.

Bore 5 - 0-2.1 m: Sand. 2.1-2.4 m: Clay. 2.4-2.9 m: Silt with clay laminae. 2.9-3.3 m: Sand.

Exposures

Sites 26 and 27 - Excavations in till (Fig. 61) described in Chapter 5.10.4.

Site 28 - Sand-pit described by Thuning (1980). In a 200 m long and 10-15 m high section, beds of gravelly sand (Appendix 2: L20) and sand alternate with beds of silt in which some clay laminae occur. The beds dip 15° toward the north. Trough cross-lamination and ripple lamination indicate a paleocurrent from the north. A bed of till, extending along the bedding planes of the stratified drift, was observed.

Site 29 - Sand-pit, displaying beds of sand alternating with beds of fine-sandy silt (Rydenheim 1973).

Site 30 - Road-cut showing a 1 m thick bed of till overlying a 1 m thick bed of sand (G. De Geer 1889a).

Site 31 - Exposure at brook in laminated and folded sand (Appendix 2: L21) described by Thuning (1980). A bed of till occurs in the sand (Appendix 2: L22).

Site 32 - Exposure along brook displaying sand with clay laminae (G. De Geer 1889a).

Site 33 - Exposure which is largely covered by scree. Diffuse ripple lamination (xy plane: type A, yz plane: troughs) suggest a paleocurrent toward the southeast.

Site 34 - Clay-pit in varved clay described by G. De Geer (1889a). The clay is at least 3.4 m thick and is overlaid by a 1 m thick bed of sand.

Site 35 - Sand-pit in which G. De Geer (1889a) observed the following sequence described from the ground surface and downward. 0-0.2 m: Sand. 0.2-1.0 m: Varved clay. 1.0-6.0 m: Sand.

Site 36 - Clay-pit in an at least 3 m thick bed of varved clay (G. De Geer 1889a).

Site 37 - Clay-pit in which G. De Geer (1889a) observed a 2.7 m thick bed of varved clay underlain by an at least 0.3 m thick bed of sand. A 0.4 m thick bed of sand covers the clay.

Site 38 - Exposure at brook showing varved clay underlain by sand (G. De Geer 1889a).

5.6.6 Subarea 6E. Discussion

Before the fluvial erosion, the sand in the valley south-southwest of Degeberga had an even surface that sloped toward the north-northeast and reached about 100 m a.s.l. at the southern boundary of subarea 6E and about 65 m a.s.l. at the mouth of the valley (Thuning 1980). Thuning concluded that the sand accumulated in a lake that was dammed by the ice sheet receding toward the north-east. He found that the ice margin during the recession of the ice sheet was lobate in the valley and formed a bay at the mouth of the valley (Fig. 34). The lobate shaping of the margin could be assumed by, among other things, the absence of sand at low levels at the eastern valley side. The bay was indicated by the morphology of the glaciofluvial deposits around Degeberga (Fig. 32B). According to Thuning, the increased number of

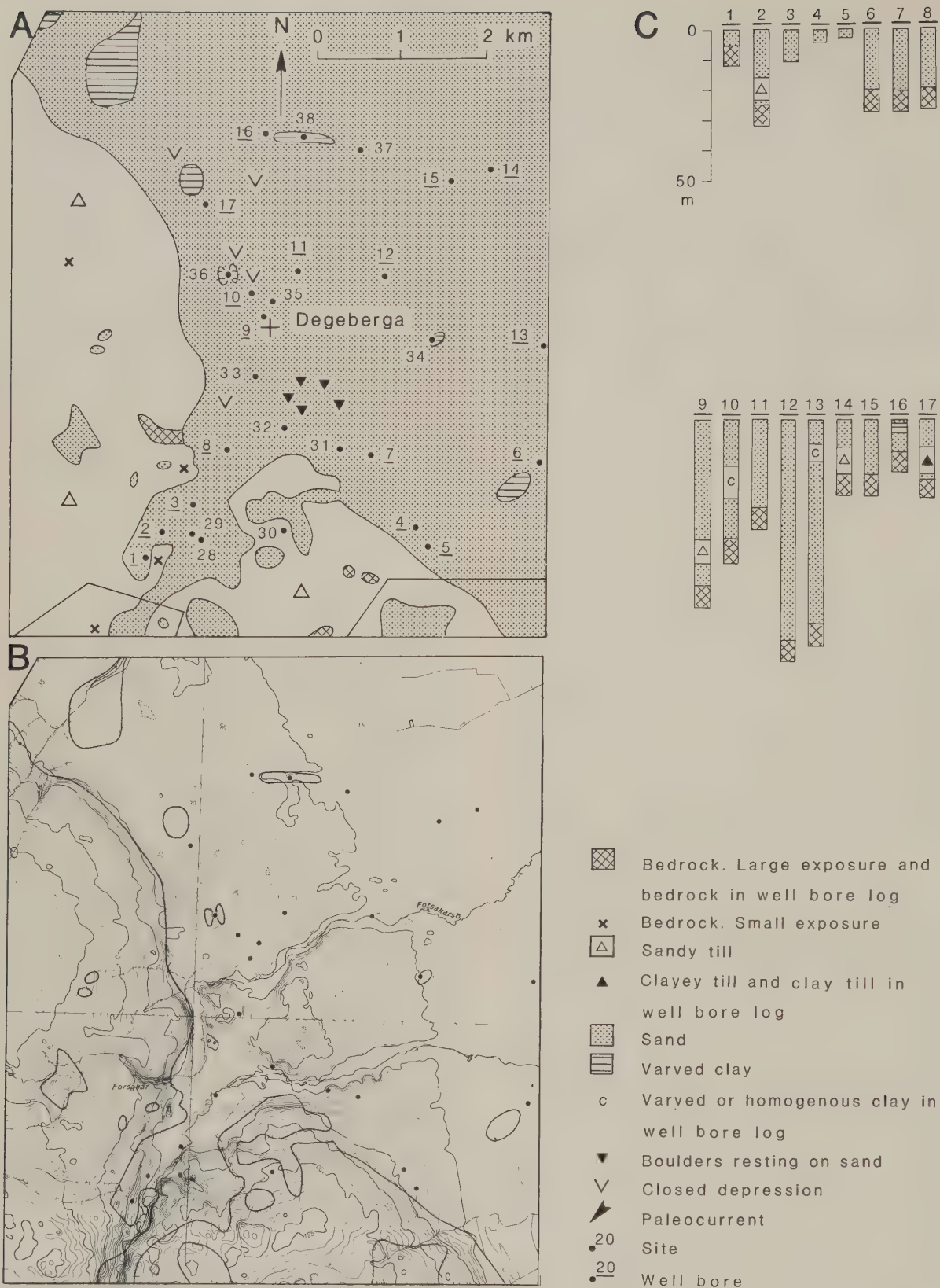


Fig. 32. Subarea 6E. A. Geology. B. Morphology. The contour interval is 5 m. Boundaries between different types of drift as well as the location of sites and well bores is indicated. C. Well bore logs.

boulders below 57 m a.s.l. on the northeast slope of the mound 1 km southeast of Degeberga was due to wave-washing and the bound-

ary at 57 m a.s.l. indicated the highest level reached by the Baltic Ice Lake.

The location of the sand in and at the

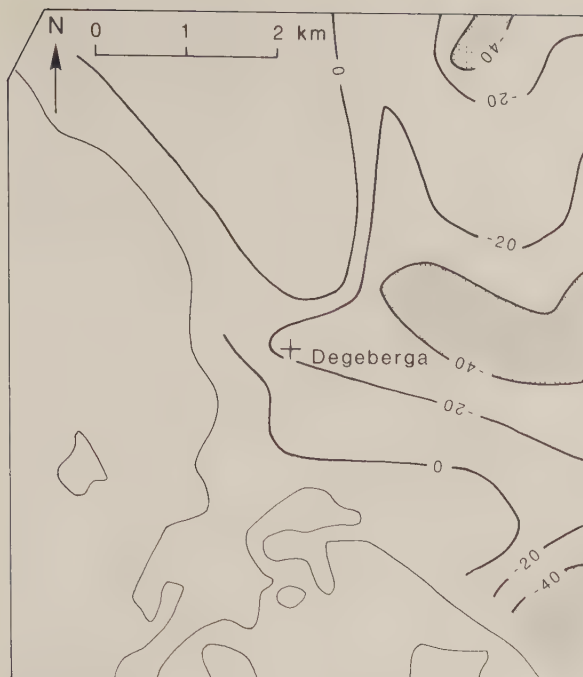


Fig. 33. The shaping of the Cretaceous bedrock surface in subarea 6E based on well bore logs. The contour interval is 20 m. Levels below -40 m are shaded. The boundaries between till and stratified drift are indicated.

mouth of the valley south-southeast of Degeberga can be explained if the sand was transported by subglacially flowing meltwater streams, because the valley and its continuation in the Cretaceous bedrock east of Degeberga may have controlled such meltwater streams.

Unlike in subarea 6E, the northeast-southwest trending valleys with glaciofluvial deposits in area 1 (Fig. 8) and in area 2 (Fig. 10) do not continue northeast of the horst. Glaciofluvial deposits do not occur at or northeast of the valley mouth in area 1. The glaciofluvial deposits at or northeast of the mouth of the valley in area 2 are not thicker than in the surroundings. This and the large quantities of stratified drift in the valley at and east of Degeberga indicate that the ice sheet above all was drained along valleys where such occur.

It is unlikely that the sand was deposited by supraglacial meltwater streams or meltwater streams flowing along the ice margin when the ice sheet terminated on the horst, because in this case not only sand but also coarser sediments ought to have accumulated in the valley. However, bore logs show that only sand is found here. Further on, the lake was at least 50 m deep, which means that the drift ought to have been dumped into the lake. This cannot have taken place, however, since the log for auger bore 3 indicates sand with strata of silt and clay.

The up-slope flow of meltwater that transported and deposited the sand in subarea 6E shows that the ice sheet had a sloping surface and, consequently, was active during the recession in subarea 6E. Since the sand in the valley south-southwest of Degeberga reaches 100 m a.s.l. at the southern boundary of subarea 6E and 65 m a.s.l. at the mouth of the valley, it follows that the deposition



Fig. 34. The deglaciation of subarea 6E according to Thuning (1980).

of the sand took place by gradual stages toward the north-northeast and. Consequently, the ice sheet receded by gradual stages in this direction.

The clay that makes up the varved clay overlying the sand in subarea 6E ought to have been transported by meltwater streams flowing at the base of the ice sheet, since the coarser sediments were transported here. Auger bore logs indicate alternating strata of silt and sand (bore 3-5) and laminae of clay occurring in the sand (bore 3). The sand at site 28 contains laminae of clay. The varved clay indicates seasonal fluctuations in the meltwater discharge of the ice sheet as do most likely the clay laminae and the silt strata in the sand. According to Sugden & John (1976), a glacier melts mainly at the surface. The surface melting is restricted to the summer half, whereas basal meltwater is produced in equal amounts throughout the year. On the basis of this, one may assume that surface meltwater penetrated the ice sheet and flowed along its base during the deposition of the stratified drift in subarea 6E. This indicates that at least a marginal zone of the ice sheet was at the pressure melting point throughout when subarea 6E was deglaciated.

5.7 Area 7. The Andrarum area

Around and south-southwest of Andrarum (Fig. 35), area 7 is occupied by a north-northeast - south-southwest trending depression that is 2-4 km wide, 15-25 m deep and has a southward sloping floor. The ground surface in the surrounding areas slopes toward the depression and is gently undulating. East of Andrarum, area 7 is dissected by a valley with an eastward-sloping floor. The valley trends east-west in the area west of Brösarp. It is here 3-4 km wide and 100 m deep. East of Brösarp, the valley splits into two

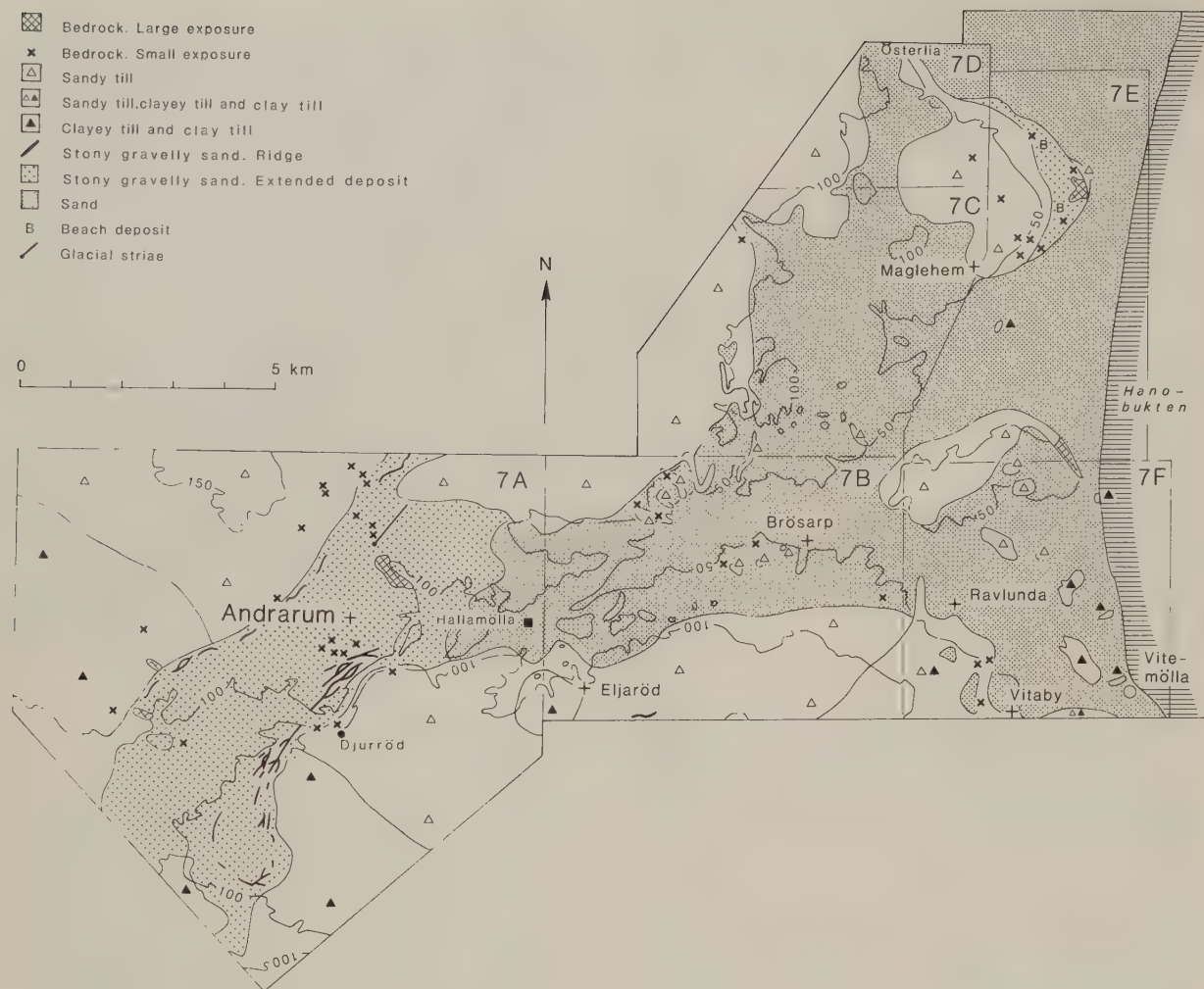


Fig. 35. Area 7, the Andrarum area. Geology and morphology. The contour interval is 50 m. Subareas 7A-7F are indicated.

branches. The branch east of Brösarp trends east-west, is 2-5 km wide and 50 m deep. The branch northeast of Brösarp, trends north-east-southwest, is 1-3 km wide and is about 50 m deep. A northeast-southwest trending ridge separates this branch from a depression southwest of Maglehem.

Precambrian gneiss dominates the bedrock (Fig. 59). Precambrian mica quartzite is exposed northeast of Ravlunda. Cambrian sandstone, Cambrian and Ordovician alum shale and Ordovician and Silurian shale are found in the western part of area 7. The bedrock beneath the stratified drift east of Rösum and Maglehem is poorly known and is discussed in Chapter 5.10.2. Cretaceous limy sandstone, sandy limestone and limestone outcrop in the area northeast of the horst.

Glacial striae north of Andrarum indicate an ice movement from the northeast (Holmström 1904).

The ground surface in the till-covered areas is gently undulating and the till forms mainly a cover reflecting the irregularities of the underlying bedrock surface. According to Bergdahl (1953), northwest-southeast trending ridges made up mainly of till but also of stratified drift occur in subarea 7A. Bergdahl stated that they formed a 1 km wide zone which started at a point located about 5 km southeast of Andrarum and crossed sub-

area 7A in a northwesterly-southeasterly direction. In the zone, a gap occurred in the area covered by stratified drift south of Andrarum. I have not been able to locate the ridges described by Bergdahl except for a northwest-southeast trending ridge situated 2 km southeast of Andrarum. The ridge is 1.2 km long, 100-150 m wide and up to 10 m high.

Well bore logs show that the till on the horst is 5-20 m thick. Up to 30 m thick till beds occur below the sand in the area east of Maglehem. The till is sandy where it is underlain by gneiss and sandstone, except for in the area south of Ravlunda where clayey till rests on gneiss. The largest outcrops of clayey till and clay till are found at Eljaröd and in the area south of Andrarum. The till here is underlain by alum shale and shale. The clay till southeast of Maglehem and in the area east of Ravlunda rest on sandy stratified drift. Well bore logs indicate that clayey till or clay till occurs beneath the stratified drift northeast of Maglehem.

The glaciofluvial deposits are located in the depressions and the valley described above. In the area around and southwest of Andrarum, the deposits are made up of stony gravelly sand forming ridges, mounds, hummocks and accumulations with a gently undulating surface. The deposits are dissected by

ravines and an erosion channel is found south of Andrarum. In the area north of Andrarum, the surface of the stratified drift is located 100–125 m a.s.l. and in the southern part of subarea 7A, 75–120 m a.s.l. Sand dominates the stratified drift in the rest of area 7, but stony gravelly sand, silt and clay are also found. The stony gravelly sand is most frequent in the area west and north of Brösarp, whereas silt and clay are common mainly in the area east of Brösarp. The sand is dissected by the Verkaån Stream and a large number of brooks. The parts of the sand which are uninfluenced by fluvial erosion reach 100–110 m a.s.l. west and north of

Brösarp, 25–40 m a.s.l. in the area east of Ravlunda and 25 m a.s.l. south of Maglehem. The glaciofluvial deposits are described at length in Chapter 5.7.1–5.7.6.

Northeast of Maglehem, a beach deposit of stony gravelly sand is found. It is 4 km long and up to 0.6 km wide. Exposures show that the deposit is 1–2 m thick (Rydenheim 1973). Up to 1 m high beach ridges are frequent and G. De Geer (1889a) registered 16 ridges between 10 and 41.8 m a.s.l. 2 km northeast of Maglehem. Beach sand overlies the glaciofluvial sand along the coast-line and it reaches up to about 30 m a.s.l.

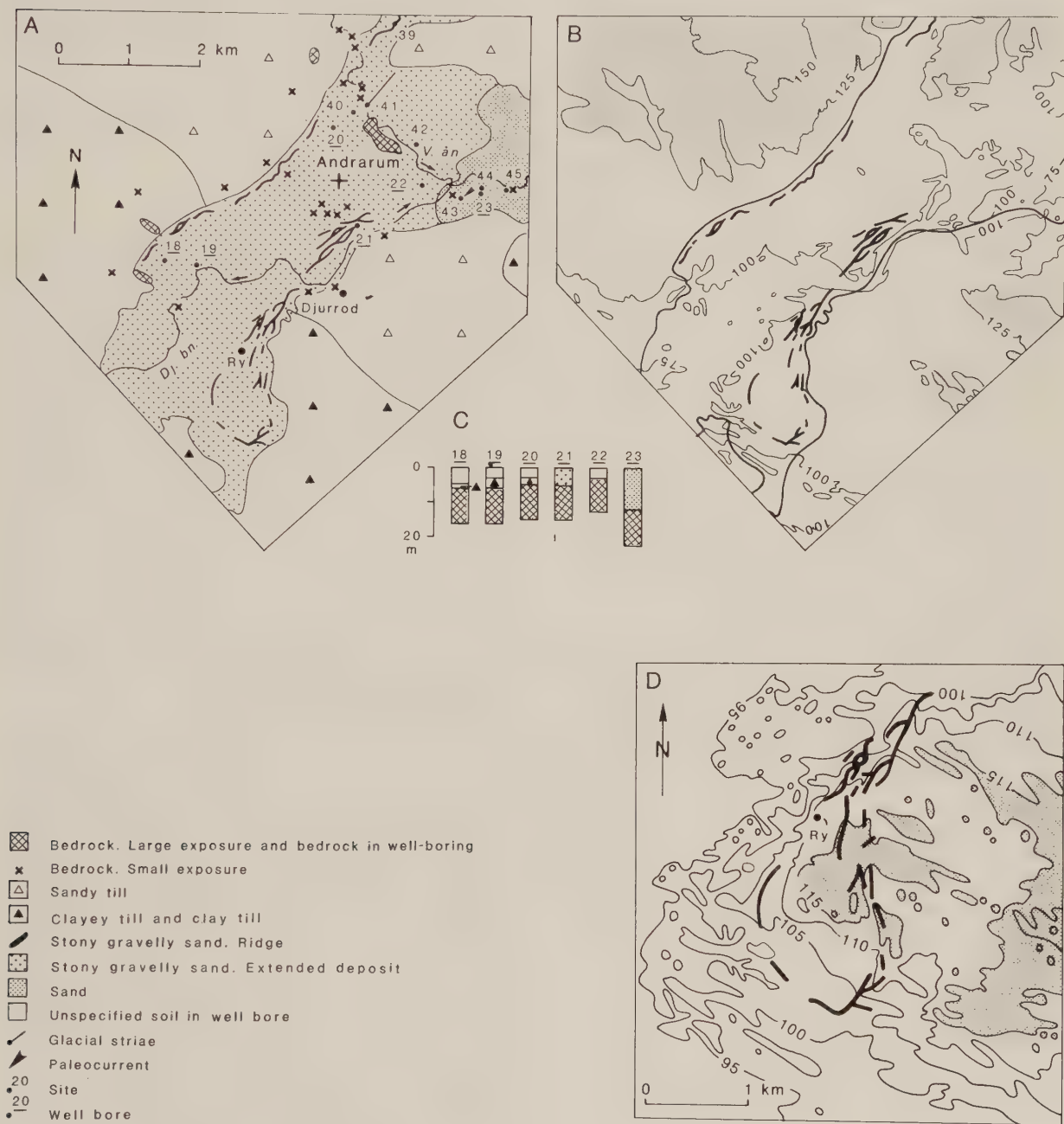


Fig. 36. Subarea 7A. A. Geology. V. ån = Verkaån, Dj. bn. = Djurrödsbäcken. B. Morphology. The contour interval is 25 m. Areas above 125 m a.s.l. are shaded. Ridges of stratified drift and boundaries between extended deposits of stratified drift and till are indicated. C. Well bore logs. D. The ridges of stratified drift at Ry. The contour interval is 5 m. Contour lines below 95 m a.s.l. are not shown. Areas above 115 m a.s.l. are shaded.

5.7.1 Subarea 7A

General description

The ravines in which the Verkaån Stream and the Djurrödsbäcken Brook run, bedrock exposures and well bore logs indicate that a bedrock threshold exists in the area around Andrarum (Fig. 36). From here the bedrock surface slopes toward the southwest and the east.

The glaciofluvial deposits are made up mainly of stony gravelly sand. In parts of subarea 7A, it is only some meters thick. According to Bergdahl (1953), till-like material is found in the area southwest of Andrarum. At site 44, till overlies sand and silt. The transition between the stony gravelly sand and the sand east of Andrarum is gradual and, therefore, the boundary in Fig. 36A is only approximate.

Mainly mounds, hummocks and closed depressions make up the morphological elements of the extended deposits of stony gravelly sand, but accumulations with a gently undulating surface also occur. The mounds and the hummocks are 20-300 m in diameter, 2-10 m high and sometimes elongated. They are found isolated or in groups. Several small hummocks lying closely together may form a mound.

Two zones with northeast-southwest trending ridges of stony gravelly sand occur in subarea 7A. The western zone is found in a 300-500 m wide and about 15 m deep depression, located in the prolongation of the valley in area 6 (Plate 1). The ridges, which have triangular cross-sections, are as much as 300 m long, about 30 m wide and 5 m high. South-southeast of Andrarum, the eastern zone is situated in a depression. The floor of the depression slopes toward the northeast, northeast of the zone with ridges. In the area around Ry, the eastern zone is located on a height (Fig. 36D). The ridges are up to 1 km long, 100 m wide and as much as 15 m high. Sharp-crested ridges of constant width and height for as much as 500 m occur. Ridges that vary in width and height are found especially in the area around Ry where the ridges merge into hummocky deposits.

The Djurrödsbäcken Brook runs in a 200-300 m wide, 15 m deep and winding erosion channel. The floor of the channel slopes toward the south. Northeast of Djurröd, the channel splits into two smaller channels. In a northeasterly direction, the channels become shallower and disappear among the hummocks and closed depressions occurring southeast of Andrarum.

Glacial striae

Site 41 - Glacial striae indicating an ice movement from 36° (Holmström 1904). The striae were observed on an exposure of alum shale that was covered by a bed consisting of fragments of alum shale.

Exposures

Site 39 - A 500x50 m large and up to 3 m deep gravel-pit in a ridge. Mainly horizontal beds of stony gravel, stony gravelly sand and sand were observed in the pit.

Site 40 - A gravel-pit, the walls of which largely are covered by scree. A 30 m long and 3 m high section shows stony gravel.

Site 42 - A 50x50 m large and 7 m deep

sand-pit. The walls of the pits are covered mainly by scree, but exposed sections display gravelly sand.

Site 43 - A 50x20 m large and 5 m deep pit in sand with horizontal bedding. Gravelly sand (Appendix 2: L23) and sand with flat lamination and trough cross-lamination predominate but medium and fine sand with ripple lamination also occur. The ripple lamination (xy plane: type A, yz plane: troughs) indicates on an average a paleocurrent from 50°.

Site 44 - A 40x40 m large and 10 m deep sand-pit. The pit-walls are largely covered by scree. A fresh cut at the base of the pit displays sand and silt with laminae of clay. Gravelly sand (Appendix 2: L24) occurs in the upper part of the pit-walls. It is overlaid by a 1 m thick bed of sandy till with angular stones and boulders.

Site 45 - A 50x25 m large and 10 m deep sand-pit. Gravelly sand (Appendix 2: L25) and sand with horizontal beds of stony gravelly sand are found here.

Discussion

The glaciofluvial deposits in subarea 7A are mainly located in depressions. Since the relative relief is low, it follows that the meltwater which transported the glaciofluvial sediments flowed in contact with till or bedrock (cf. Chapter 5.6.4). Thus, the meltwater flowed in an up-slope direction in the areas around Ry and east of Andrarum. Therefore, the meltwater which transported the glaciofluvial sediments flowed along the base of an ice sheet with a sloping surface.

The glaciofluvial sediments must have accumulated in connection with stagnant glacier ice, as they show no signs of disturbance from active ice. The morphology of the hummocky deposits indicates that parts of the sediments making them up were overlaid originally by glacier ice. However, the ice must have been thin and disintegrating, since these deposits mainly are located in a shallow depression and the sediments were transported by subglacial meltwater streams (cf. Chapter 5.6.4 and Fig. 26).

The stratified drift making up the ridges accumulated in a non-disintegrated or only slightly disintegrated part of the ice sheet, as the ridges indicate well-defined meltwater conduits (cf. Chapter 5.6.4). Since the ridges at Ry merge into hummocky deposits and the glaciofluvial sediments occurring here were transported by meltwater flowing in an up-slope direction, it follows that a well-defined boundary zone between disintegrating and non-disintegrated glacier ice ought to have existed in this area when the ridges and hummocky deposits were formed (cf. Chapter 5.6.4).

The up-slope flow of the meltwater which transported the sediments making up the glaciofluvial deposits can only have taken place in non-disintegrated glacier ice. This and the accumulation of stratified drift with a hummocky morphology in connection with disintegrating glacier ice show that the ice sheet receded by gradual stages in subarea 7A.

The trend of the zone with ridges at Ry shows that the ice surface sloped in a southerly direction here when the glaciofluvial sediments accumulated, as the low relief in the area east of Ry cannot have controlled the main flow direction of the subglacial meltwater.

The existence of subglacial meltwater during the recession of the ice sheet in subarea 7A shows that the ice sheet was mainly at the pressure melting point at least at the base then.

5.7.2 Subarea 7B

General description

The stratified drift is predominantly by sand (Fig. 37). Gravel occurs along with the sand in the western part of subarea 7B and silt with clay laminae is common in the eastern part. Boulders often rest on sand in the ground surface, but have not been observed in exposures. A some meters thick bed of stony gravelly sand with an even surface is found in the central part of the valley around the Verkaån Stream. Ravines, eroded by brooks running into

the Verkaån Stream, dissect the sand. Till and bedrock are rather often exposed in the bottom of the ravines. The boundary between the sand and the surrounding till is mostly situated 100-105 m a.s.l. in the western part of subarea 7A. The ground surface between the ravines found here is even. It is also located 100-105 m a.s.l. In the area south of Brösarp, the boundary between the till and the sand is found at 75 m a.s.l. Here, the sand forms mounds between the ravines. North of the Verkaån Stream in the northeastern part of subarea 7B, the surface of the sand is located 40-80 m a.s.l.

A roughly east-northeast - west-southwest trending ridge of stony gravelly sand is found 5 km southwest of Brösarp. It is located southwest of a depression, the floor of which slopes toward the northeast, 500 m northeast of the ridge. The ridge is about 600 m long, less than 30 m wide and up to 4 m high.



Fig. 37. Subarea 7B. A. Geology. B. Morphology. The contour interval is 5 m. The boundaries between different types of drift as well as the location of sites and well bores are shown. C. Well bore logs.

Exposures

Site 46 - A 10x10 m large and 3 m deep sand-pit, the walls of which are mainly covered by scree. Cleaned sections show sand and some stony gravelly sand (Appendix 2: L27).

Site 47 - A 50x25 m large and 10 m deep sand-pit. Sand and gravelly sand with horizontal beds of stony gravelly sand and silt predominate. Laminae of clay occur in the silt. The gravelly sand (Appendix 2: L28) and coarse sand are flat laminated or trough cross-laminated. Ripple lamination (xy plane: type A, yz plane: troughs) is found in medium and fine sand. The trough cross-lamination and the ripple lamination indicate a paleocurrent from on an average 45°.

Site 48 - A 5 m long and 5 m high exposure at the Verkaän Stream displaying horizontal beds of stony gravelly sand, sand and silt. Trough cross-lamination in gravelly sand (Appendix 2: L29) and coarse sand indicates a paleocurrent from 45° on an average. The same direction is indicated by ripple lamination (xy plane: type A, yz-plane troughs) in medium and fine sand.

Site 49 - A 2 m long and 1 m high exposure at the Verkaän Stream showing clayey silt and gravelly sand (Appendix 2: L30).

Site 50 - A small exposure in a ravine displaying fine sand with ripple lamination (xy plane: type A, yz plane: troughs, xz plane: irregular lunate rib lamination). The ripple lamination indicates a paleocurrent from 55°.

Site 51 - A small exposure in fine sand with ripple lamination (xy plane: type B, yz plane: troughs and wavy parallel lamination) indicating a paleocurrent from 20°.

Site 52 - A small exposure in sand and silt. Laminae of clay occur in the silt.

Site 53 - A pit-wall described by T. Nilsson (1961) displaying mainly sand and silt. The beds of silt are irregularly wavy. Along one bedding plane, beds of sandy poorly-sorted material with stones and a small amount of clay occur (Appendix 2: L31). Below the beds of poorly-sorted material, high-angle faults are common in the sand and the silt.

Site 54 - A 15 m deep bore in slightly clayey sand (G. De Geer 1889b).

Site 55 - A 3 m long and 2 m high exposure showing alternating laminae and thin beds of fine sand and silt. One lamina of clay was observed.

Site 56 - A gravel-pit in stony gravelly sand (Appendix 2: L32).

Site 57 - A 100 m long and 15 m high exposure largely covered by scree and located by the Verkaän Stream. In the lower part of the exposure, beds of fine and medium sand with ripple lamination alternate with beds of silt containing clay laminae. The bedding is disturbed by sliding. In the upper part of the exposure, G. De Geer (1889a) observed a 4 m thick bed of sand with 25 cm thick beds of clay.

Site 58 - A 25x25 m large and 4 m deep sand-pit. The pit-walls are largely covered by scree but cleaned sections display sand



Fig. 38. Ripple lamination in a horizontal cut (the xz plane) at site 59 in subarea 7B. The cut displays parallel lamination, lunate rib lamination and circular lamination. The ripple-laminated sand was deposited by a paleocurrent from about the south-south-east.

with trough cross-lamination indicating a paleocurrent from on an average 70°. The sets are 10-30 cm thick.

Site 59 - An exposure in a ravine with horizontal strata of medium sand, fine sand and silt with clay laminae. Two paleocurrent analyses in medium sand with ripple lamination (xy plane: type A and B, yz plane: troughs, xz plane: parallel lamination, lunate rib lamination and circular lamination) indicate a paleocurrent from 160° and 280° respectively. Figure 38 shows a horizontal cut (the xz plane) in the ripple laminated sand indicating a paleocurrent from 160°.

Site 60 - A pit displaying horizontal beds of alternating medium sand, fine sand and silt. Ripple lamination (xy plane: type A, yz plane: troughs) indicates a paleocurrent from 330°.

Site 61 - A 4 m long and 3 m high exposure, in the upper part of which horizontal strata of fine sand and silt alternate. In the lower part, medium sand with ripple lamination (xy plane: type A, yz plane: troughs) occurs. The ripple lamination indicates a paleocurrent from 30°.

Site 62 - A 10 m long and 1.5 m high exposure displaying sand and silt.

Site 63 - A 50x25 m large and 7 m deep sand-pit. The pit-walls are mostly covered by scree. Cleaned sections display sand and silt.

Discussion

In the western part of subarea 7B, the valley was filled with sand before it was dissected by the Verkaän Stream, since the boundary between the sand and the surrounding till reaches the same level as the sand surface between the ravines. In the eastern part of subarea 7B, the valley was filled with sand up to 50-75 m a.s.l.

The glaciofluvial sediments accumulated in standing water, as they are predominated by sand and contain silt with laminae of clay. The occurrence of gravel in the sand indicates sedimentation close to the margin of the ice sheet. Stagnant ice did not occur in the western part of the valley, as the sand here originally filled the valley. However, the

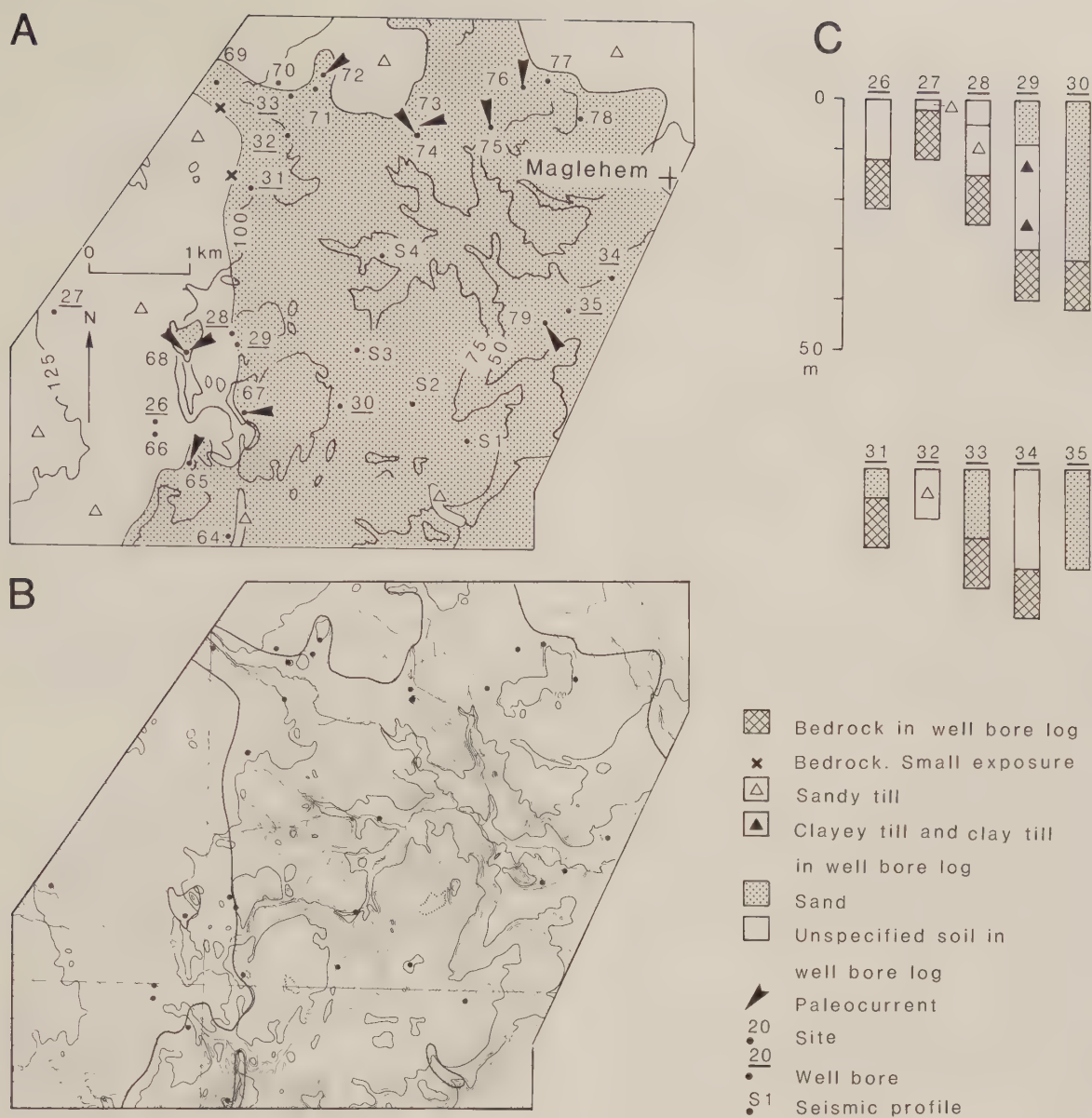


Fig. 39. Subarea 7C. A. Geology. B. Morphology. The contour interval is 5 m. The boundaries between different types of drift as well as the location of sites, well bores and seismic profiles are shown. C. Well bore logs.

mounds south of Brösarp indicate that stagnant ice existed here during the accumulation of the stratified drift. The ice sheet ought mainly to have terminated in a cliff, as the thickness of the stratified drift shows that the depth of the ponded water was at least 50 m.

The horizontal bedding and the lamination of the stratified drift indicate that the sediment-transporting meltwater currents moved along the bottom of the basin with the ponded water. This means that the ice sheet was drained subglacially, since it terminated in a cliff.

5.7.3 Subarea 7C

General description

Well bore logs, seismic investigations and ravines indicate that the stratified drift in

subarea 7C (Fig. 39) is mainly located in a depression. The brooks in the area southwest of Maglehem have dissected only stratified drift and probably reached down to the underlying till which is indicated by the seismic profiles S1 and S3 (Figs. 39 and 45). Further on, boulders are more frequent at some places in the bottoms of the ravines than on the surface of the surrounding stratified drift. The depression in the southern part of subarea 7C is bounded by one east-west trending bedrock ridge located southwest of Maglehem and one northeast-southeast trending bedrock ridge situated south-southwest of Maglehem. These ridges are indicated by till exposed in the bottoms of some of the ravines occurring here. It is likely that the bottoms in the rest of the ravines consist of till or bedrock covered by a veneer of sand, since the ravines are shallow and have steeply sloping floors.

Mainly sand makes up the stratified drift

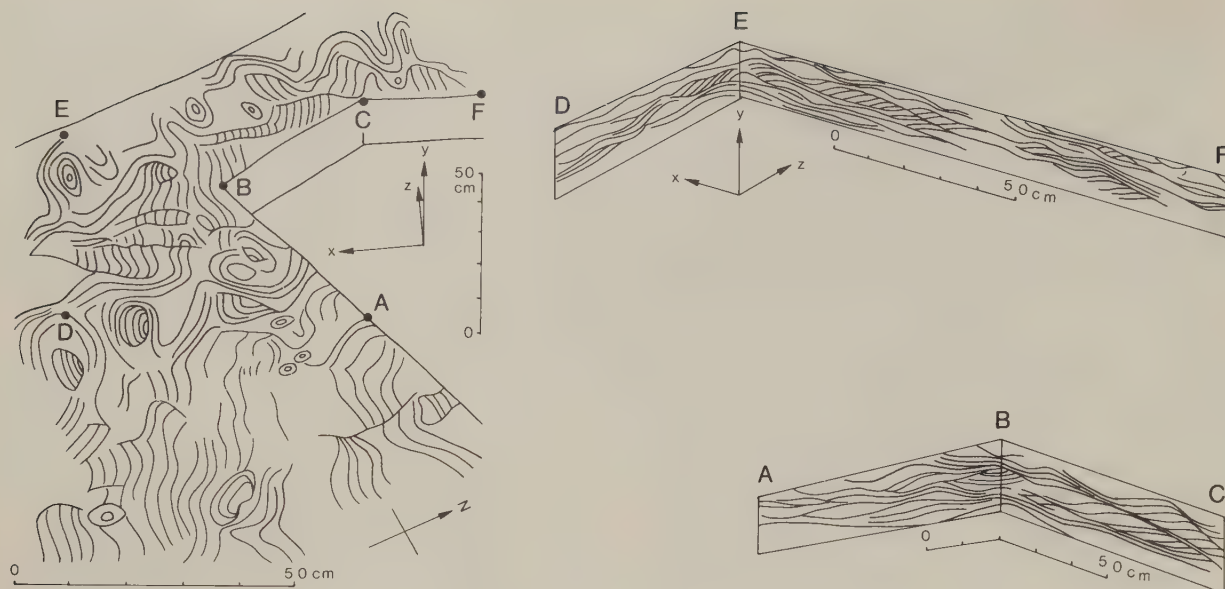


Fig. 40. Ripple lamination at site 65 in subarea 7C. A. Horizontal surface (the xz plane) showing wavy parallel lamination, lunate rib lamination and circular lamination. B. Vertical surfaces displaying lamination of type B in the xy plane and troughs and wavy parallel lamination in the xz plane. The position of the vertical surfaces is indicated in Fig. 41A. A paleocurrent from 20° is indicated.

but stony gravelly sand and silt also occur. The stony gravelly sand is especially found in the eastern and northern parts of subarea 7C and the silt in the western and central parts. Well bore logs and seismic investigations show that the sand is mainly 10–30 m thick. This is also shown by the mounds and the plateaus of stratified drift which often are more than 20 m high.

Plateaus, mounds and closed depressions constitute the morphological elements of the stratified drift. A large mound is often made up of several smaller mounds lying closely together. The surfaces of the mounds are hummocky to a varying degree. The top surfaces of the mounds and the plateaus are situated 5–20 m above the surface of the till in the western and northern parts of subarea 7C. Along the western boundary between sand and till, the sand rises in steeply dipping slopes above the till. Along the northern boundary, the slopes dip more gently.

Exposures

Site 64 – A 50×40 m large and 8 m deep gravel-pit. The pit-walls are largely covered by scree. Cleaned sections display gravelly sand (Appendix 2: L33) with cross-lamination.

Site 65 – A 70×70 m large and 5 m deep pit. The pit-walls are covered by scree. An excavation in the pit-floor (Fig. 40) show fine sand with ripple lamination (xy plane: type B, yz plane: troughs and wavy parallel lamination, xz plane: wavy parallel lamination, lunate rib lamination and circular lamination). The ripple lamination indicates a paleocurrent from 20°. The fine sand is underlain by gravelly sand (Appendix 2: L34).

Site 66 – Excavation in till (Fig. 61) described in Chapter 5.10.4.

Site 67 – A 60×60 m large and 5 m deep pit

in sand with flat lamination and ripple lamination. Some beds of gravelly sand occur (Appendix 2: L38). Ripple lamination (xy plane: type B, yz plane: wavy parallel lamination, xz plane: straight rib lamination) indicates paleocurrents from between 80° and 90°. One of the excavations with ripple-laminated sand is shown in Fig. 41.

Site 68 – Site 68 is located in a mound surrounded by till. A part of the surface of the mound is horizontal and reaches about 105 m a.s.l.

The site comprises two pits. Sand predomi-

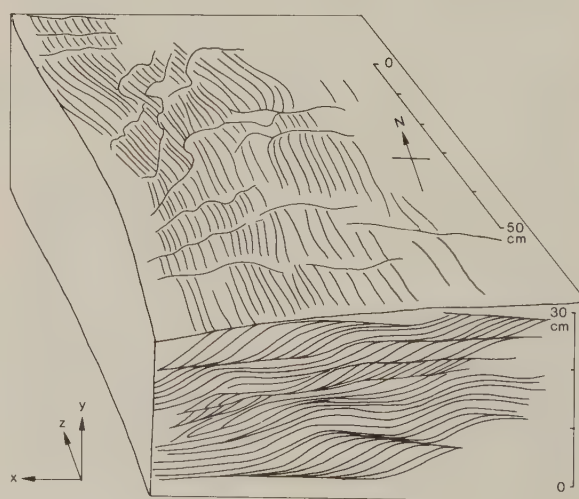


Fig. 41. Ripple lamination at site 67 in subarea 7C. Straight rib lamination is seen in the horizontal surface (the xz plane) and type A and type B lamination in the vertical surface (the xy plane). A paleocurrent from 80° is indicated.

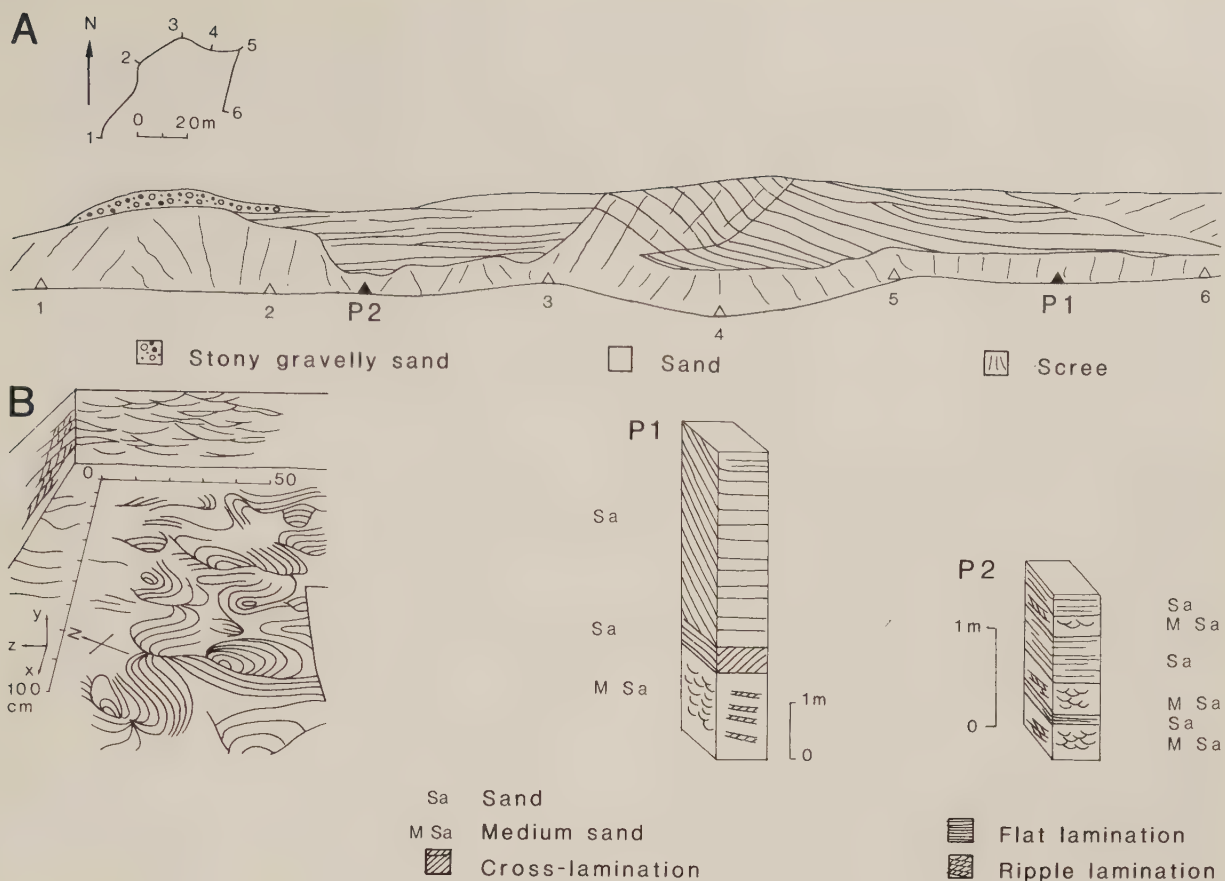


Fig. 42. The southern pit at site 68 in subarea 7C. A. Section 1-6. Profile 1 (P1) and profile 2 (P2) are close-ups of the stratification. B. Ripple lamination (xy plane: type A, yz plane: troughs xz plane: circular lamination) in the lowermost sand bed in profile 1. A paleocurrent from 60° is indicated.

nates in the southern pit (Fig. 42). In the upper part of section 1-4, beds of gravelly sand (Appendix 2: L39) and sand with flat lamination are found. The beds dip 22-32° toward the southeast and indicate a paleocurrent from the northeast. In the lower part of section 1-4, a horizontal bed of medium sand with ripple lamination occurs. The ripple lamination (xy plane: type A, yz plane: troughs, xz plane: circular lamination) indicates a paleocurrent from 60°. In section 5-6, gently dipping and horizontal beds with flat-laminated coarse sand and ripple-laminated fine and medium sand occur. The ripple lamination (xy plane: type A, yz plane: troughs xz plane: lunate rib lamination) indicates a paleocurrent from 80°. In section 1-2, the sand is overlaid by a 1 m thick bed of stony gravelly sand, which before removal also covered the sand in section 2-6.

In the northern pit, horizontal beds of fine gravelly sand with trough and planar cross-lamination alternate with ripple-laminated beds of medium and fine sand, indicating a paleocurrent from roughly 45°.

Site 69 - A 10x10 m large and 3 m deep gravel-pit, the walls of which are largely covered by scree. Cleaned surfaces show horizontal beds of gravelly sand (Appendix 2: L40) and sand. The sand is flat laminated.

Site 70 - Excavation in till (Fig. 61), described in Chapter 5.10.4.

Site 71 - Clay till investigated by G. De Geer (1889a), containing fragments of Silurian shale, limestone from the island of Gotland and other Baltic indicators.

Site 72 - A 20x20 m large and 5 m deep pit with mainly scree-covered walls. An excavation

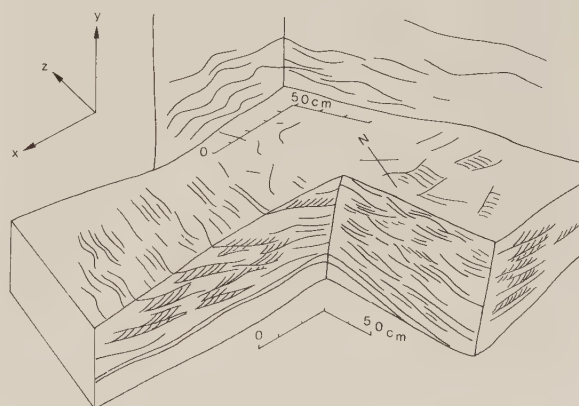


Fig. 43. Ripple lamination (xy plane: type A and B, yz plane: troughs and wavy parallel lamination, xz plane: parallel lamination and straight rib lamination) at site 72 in subarea 7C.

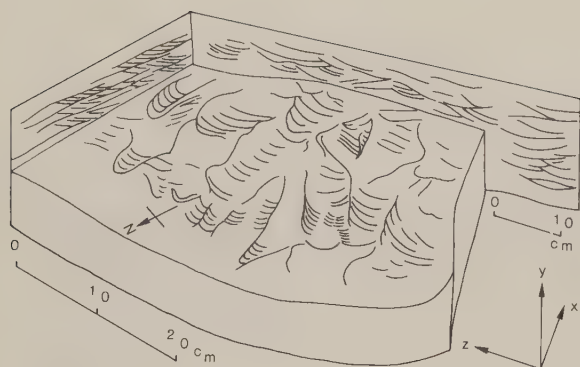


Fig. 44. Ripple lamination (xy plane: type A, yz plane: troughs, xz plane: lunate rib lamination) at site 74 in subarea 7C.

vation in the lowermost part of a pit-wall (Fig. 43) displayed fine and medium sand with ripple lamination (xy plane: type A and B, yz plane: troughs and parallel lamination, xz plane: parallel lamination and straight rib lamination) indicating a paleocurrent from 50°. The sand is overlaid by a bed of gravelly sand (Appendix 2: L45).

Site 73 - A 40 m long and 4 m high pit-wall, mostly covered by scree, located in an east-west trending ridge. Cleaned surfaces show horizontal and alternating beds of gravel without visible stratification, gravelly sand (Appendix 2: L48) with flat lamination and slightly silty medium and fine sand with ripple lamination (xy plane: type A, yz plane: troughs, xz plane: rib lamination) and silt with laminae of clay. The ripple lamination indicates a paleocurrent from 75°.

Site 74 - A 75x75 m large and 10 m deep sand-pit, the walls of which are mainly covered by scree. Cleaned surfaces show ripple lamination (xy plane: type A, yz plane: troughs, xz plane: lunate rib lamination) in medium sand, indicating a paleocurrent from on an average 320°. One of the excavations in the ripple-laminated medium sand is shown in Fig. 44.

Site 75 - A 20x20 m large and 1.5 m deep sand-pit, displaying gravelly sand (Appendix 2: L50) and sand with trough cross-lamination indicating a paleocurrent from 350°. The sets are 10-30 cm thick and the trough sets are 0.5-1.5 m wide.

Site 76 - A small pit with scree-covered pit-walls. An excavation in the pit-floor shows medium and fine sand with ripple lamination (xy plane: type A, yz plane: troughs, xz plane: lunate rib lamination and circular lamination) indicating a paleocurrent from 0°.

Site 77 - A 10x10 m large and 3 m deep sand-pit with scree-covered walls. Gravelly sand (Appendix 2: L52), sand and silt with laminae of clay are found.

Site 78 - A road-cut in sand containing silt, described by T. Nilsson (1961).

Site 79 - A small exposure displaying medium sand with ripple lamination (xy plane: type A, yz plane: troughs, xz plane: lunate rib lamination) indicating a paleocurrent from 145°.

Seismic investigations

The location of the seismic profiles is shown in Fig. 39. The seismic graphs are reproduced in Fig. 45.

S1 - V1 = 360 m s⁻¹. V2 = 600 m s⁻¹. X1 = 15 m. D1 = 3.9 m. D2min. (V3 = 1800 m s⁻¹) = 26.1 m. D2min. (V3 = 4500 m s⁻¹) = 30.6 m. The surface deposits consist of sand. Interpretation: Ground water is indicated about 4 m below the ground surface. An at least about 10 m thick bed of sand occurs.

S2 - V1 = 270 m s⁻¹. V2 = 390 m s⁻¹. V3 = 810 m s⁻¹. X1 = 9.0 m. X2 = 27.9 m. V1r =

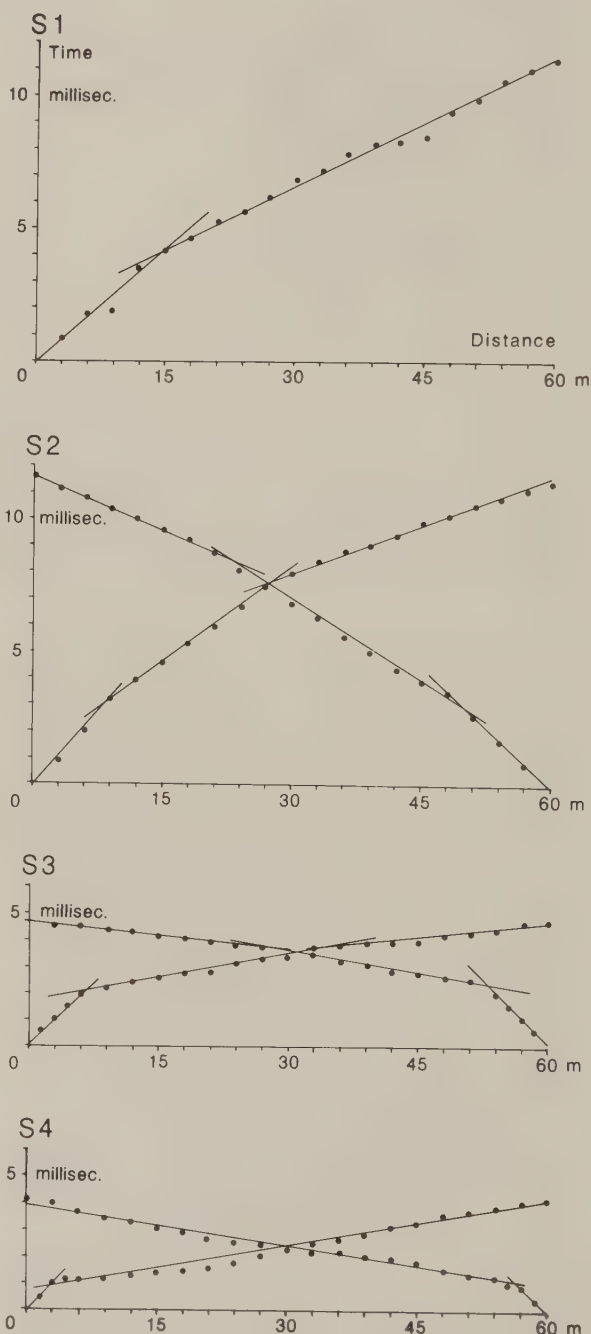


Fig. 45. Seismic graphs. The location of the seismic profiles is indicated in Fig. 39.

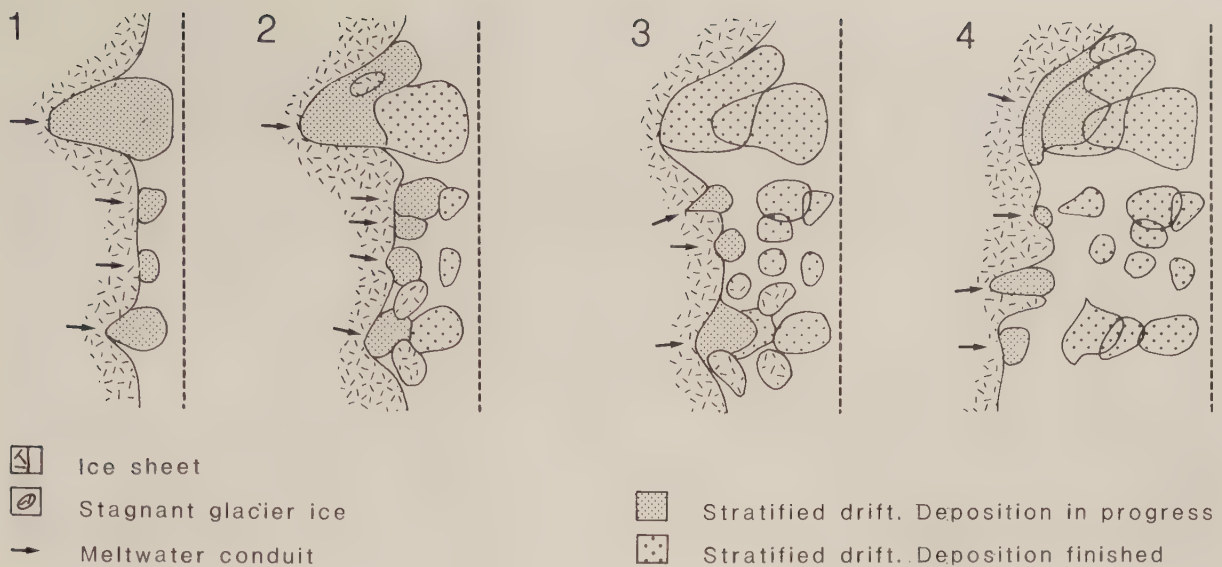


Fig. 46. A model for the deposition of the glaciofluvial sediments in subarea 7C illustrated at four successive positions of the ice margin. The dashed line is a reference line with the same position in all figures.

330 m s -1. V2r = 480 m s -1. V3r = 720 m s -1. X1r = 10.2 m s -1. X2r = 37.5 m. D1 = 2.0 m. D2 = 9.6 m. D1r = 2.1 m. D2r = 9.9 m. The surface deposits consist of sand. Interpretation: Ground water is indicated about 2 m below the ground surface. An at least about 10 m thick bed of sand occurs.

S3 - V1 = 330 m s -1. V2 = 1500 m s -1. V3 = 3000 m s -1. X1 = 6.6 m. X2 = 36.0 m. V1r = 300 m s -1. V2r = 1800 m s -1. V3r = 3000 m s -1. X1r = 6.9 m. X2r = 32.1 m. D1 = 2.7 m. D2 = 11.2 m. D1r = 3.0 m. D2r = 10.5 m. The surface deposits consist of till. Interpretation: Ground water is indicated about 3 m below the ground surface. The sand only forms a surface layer resting on till. The till is about 10 m thick and is underlaid by sedimentary bedrock or fractured crystalline bedrock.

S4 - V1 = 285 m s -1. V2 = 1800 m s -1. X1 = 3.0 m. V1r = 300 m s -1. V2r = 2100 m s -1. X1r = 3.9 m. D1 = 2100 m s -1. D2min (V3 = 4500 m s -1) = 20.8 m. D1r = 1.6 m. D2r (V3 = 4500 m s -1) = 19.5 m. The profile is located close to a brook along which boulders are found. Interpretation: Ground water is indicated about 1.5 m below the ground surface. An at least 10 m thick bed of till occurs.

Discussion

The glaciofluvial sediments accumulated in standing water for three reasons. Firstly, they are composed predominantly of sand in which silt is found. Sedimentation in a sub-aerial environment ought to have resulted in coarser deposits. Secondly, the surface of the glaciofluvial deposits is often situated at about 105 m a.s.l. except in the area south and southwest of Maglehem. Since the depth to the till or bedrock that underlies the stratified drift is varying, it follows that the sedimentation was controlled by the surface of a body of ponded water. Thirdly, the sediments were transported by meltwater flowing over the high-lying areas north of the depression in subarea 7C. This and the fact

that the top surface of the glaciofluvial deposits reach above the surface of the till north and west of the depression indicate that glacier ice did not prevent the sedimentation in the depression but did so in the surroundings. This can only be explained if meltwater was ponded in subarea 7C and the greater water depths in the depression resulted in calving of glacier ice here.

The sediments making up the glaciofluvial deposits were transported by meltwater that flowed at the base of the ice sheet, since the deposits in the area northwest of Maglehem are situated in the continuation of a depression in subarea 7D (Fig. 47).

The accumulation of the stratified drift took place by gradual stages, since stony gravelly sand is found in all of the western part of subarea 7C and stone and gravel-sized particles only are transported a short distance in standing water. This means that the ice sheet receded by gradual stages in subarea 7C.

The following model for the accumulation of the stratified drift is proposed (Fig. 46). A plateau or a complex mound consisting of several smaller mounds resulted if a large quantity of sediments was supplied. A plateau was formed if stagnant glacier ice did not occur in front of the ice margin and if the ice margin kept the same position for some time. A complex mound was formed if stagnant ice occurred in front of the ice margin or if the ice sheet receded quickly. Mounds resulted if the supply of sediments was small. Glacier ice is likely to have been included in the sediments during the accumulation, as already deposited sediments ought to have reduced the water depth.

5.7.4 Subarea 7D

General description

The glaciofluvial deposits are made up primarily of sand in subarea 7D. The main part of the sand is located in a northeast-southwest trending incision in the slope of the horst. Here, the sand is up to 20 m thick whereas

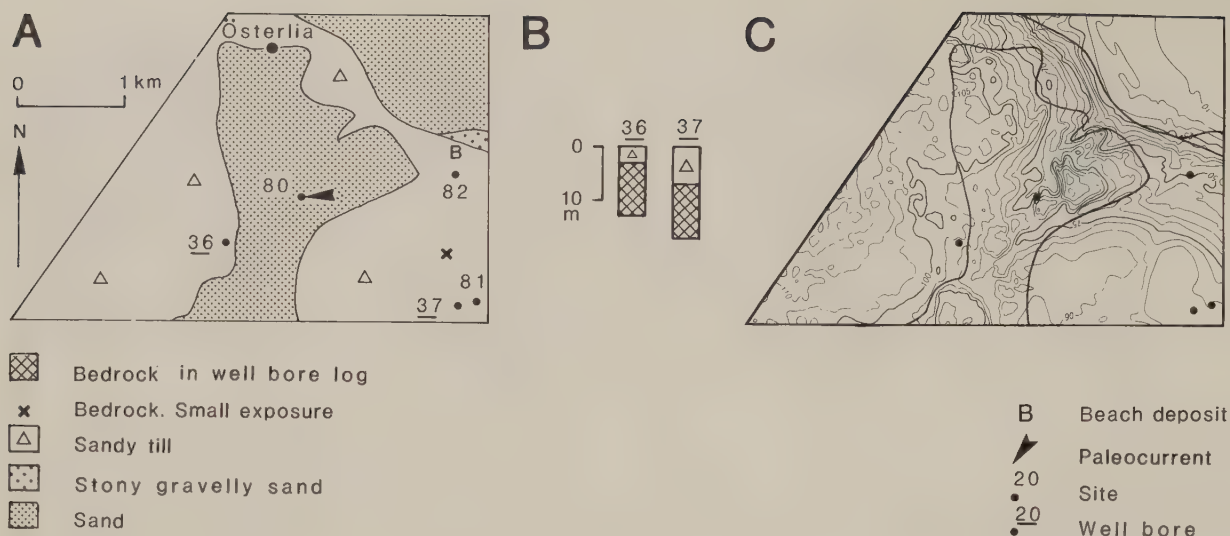


Fig. 47. Subarea 7D. A. Geology. B. Well bore logs. C. Morphology. The contour interval is 5 m. The boundaries between different types of drift as well as the location of sites and well bores are indicated.

it is only some meters thick in the area west of the incision. On the horst, the sand forms plateaus, mounds, hummocks and some meters thick accumulations with a gently undulating surface. Till is often exposed in the ravines that dissect the sand.

Exposures

Site 80 – A 80x80 m large and 4 m deep pit in sand in which beds of gravelly sand (Appendix 2: L53) and silt occur. The bedding is in part horizontal and in part folded. High-angle faults are common where folded beds are found. Ripple lamination (xy plane: type A, yz plane: troughs, xz plane: lunate rib lamination) in medium and fine sand indicates a paleocurrent from 80°.

Site 81 – An excavation in till (Fig. 61) described in Chapter 5.10.

Site 82 – A clay-pit described by G. De Geer (1889a). A 1 m thick bed of clayey till or clay till containing 'Baltic boulders' was observed in the lower part of the pit-walls. It is overlaid by a 1 m thick bed of laminated clay.

Discussion

The glaciofluvial sediments must have been transported by meltwater flowing at the base of the ice sheet, since they are mainly located in an incision in the horst. As the meltwater flowed in an up-slope direction, the part of the ice sheet in which the sediments were transported must have had a sloping surface and was not disintegrated. The fine-grained sediments indicate accumulation in standing water. The hummocks and mounds suggest that stagnant ice remained in front of the ice margin in parts of subarea 7D.

The stratified drift in subarea 7D is more fine-grained and covers a smaller area than in subarea 7C, which indicates that the sediments in subarea 7D were deposited later than in subarea 7C. Thus, the ice sheet

receded by gradual stages here.

5.7.5 Subarea 7E

General description

The glaciofluvial deposits are made up primarily of sand (Fig. 48). In the parts of subarea 7E indicated by the letter A in Fig. 48, the sand forms mounds and closed depressions. In the area indicated by the letter B, the glaciofluvial sand is overlaid by beach sand.

A bed of clay till overlies the sand at site 84 (Fig. 48). G. De Geer (1889a) named this till the upper till and correlated it with the upper till in subarea 7F (Fig. 50). The westernmost extent of the till is located east of the boundary between subareas 7E and 7C, as the till has not been observed in subarea 7C and at site 83. Further, the till is not indicated in well bore log 38.

The sand underlying the till at site 84 ought to have a considerable thickness judging by the steep slopes of the depression in which the sand is situated. Well bore log 38 shows that the floor of the depression is located at least 30 m below the ground surface.

Exposures

Site 83 – A sand-pit with mainly scree-covered walls. Cleaned sections show horizontal beds of slightly gravelly sand (Appendix 2: L59) with flat lamination, fine and medium sand with ripple lamination and fine-sandy silt with some clay laminae. The ripple lamination (xy plane: type A and B, yz plane: troughs and wavy parallel lamination) indicates a paleocurrent from 270°.

Site 84 – An exposure along the Julebodaån Stream, displaying clay till and stratified drift (Fig. 49). The site was investigated by G. De Geer (1889a) and profiles 1-3 and 7 are his. De Geer observed boulders of Palaeozoic limestone and Åland rapakivi in the till. The exposure was almost completely covered

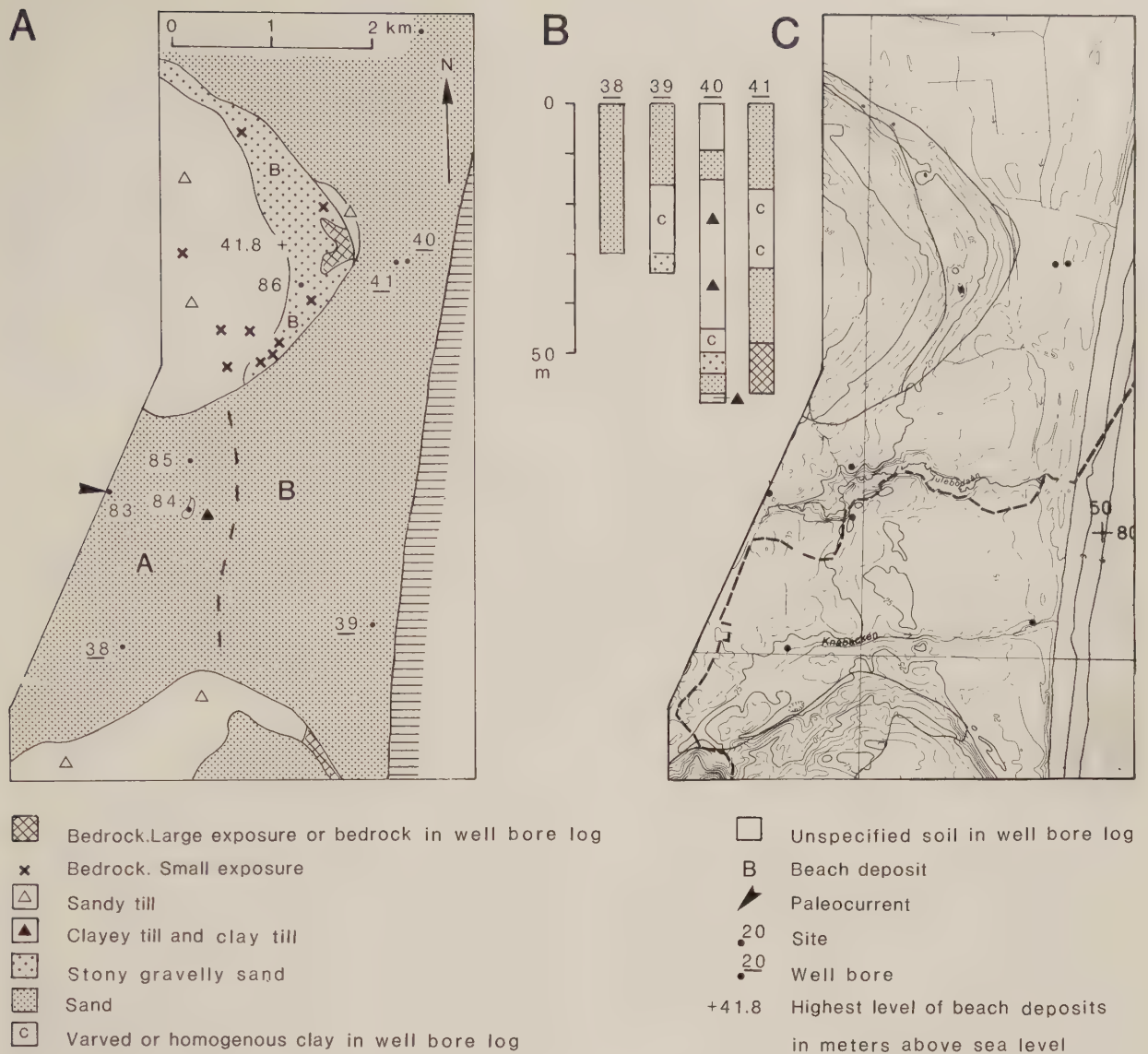


Fig. 48. Subarea 7E. A. Geology. The letters A and B are explained in the text. B. Well bore logs. C. Morphology. The contour interval is 5 m. The boundaries between different types of drift as well as the location of sites and well bores are indicated.

by scree when I viewed it. I have registered the stratigraphy in three profiles (Fig. 49: p4-p6), which are described below.

Profile 4: 0-2.8 m: Sand. 2.8-4.0 m: Scree. 4.0-5.2 m: Alternating and less than 3 cm thick strata of clay and silt. Also occurring are a 20 cm thick bed of gravelly sand and a 25 cm thick bed of massive, silty and poorly-sorted material with gravel and stones (Appendix 2: L60). 5.2-11.5 m: Scree. 11.5-12.0 m: Massive clay.

Profile 5: 0-3.0 m: Sand. 3.0-3.5 m: About 1 cm thick strata of clay alternating with about 3 cm thick beds of silt. 3.5-4.0 m: Massive, silty and poorly-sorted material with gravel and stones (Appendix 2: L61). 4.0-5.0 m: Less than 2 cm thick strata of clay alternating with less than 3 cm thick strata of silt. 5.0-12.0 m: Scree.

Profile 6: 0-2.0 m: Sand. 2.0-10.0 m: Scree. 10.0-12.0 m: Sand with flat lamination overlaid by silt with less than 2 cm thick strata of clay, shifting upward into a bed with less than 2 cm thick strata of alternat-

ing silty clay and clay.

Site 85 - Small exposure displaying the following stratigraphic sequence described from the ground surface and downward: 0-0.5 m: Gravelly sand (Appendix 2: L62). 0.5-0.9 m: Massive clay with some gravel and stones. 0.9-1.4: Gravelly sand (Appendix 2: L63).

Site 86 - A gravel-pit displaying a 1-2 m thick bed of stony gravelly sand resting on sandy till (Rydenheim 1973).

Discussion

The upper till was deposited during an advance of the ice sheet, since the till contains strata of silt and clay and is underlaid by sand, the extent and thickness of which indicates deposition in standing water. The upward-finding sequence shown by the sand underlying the till and the silt and clay in the till indicates a retreat of the ice sheet

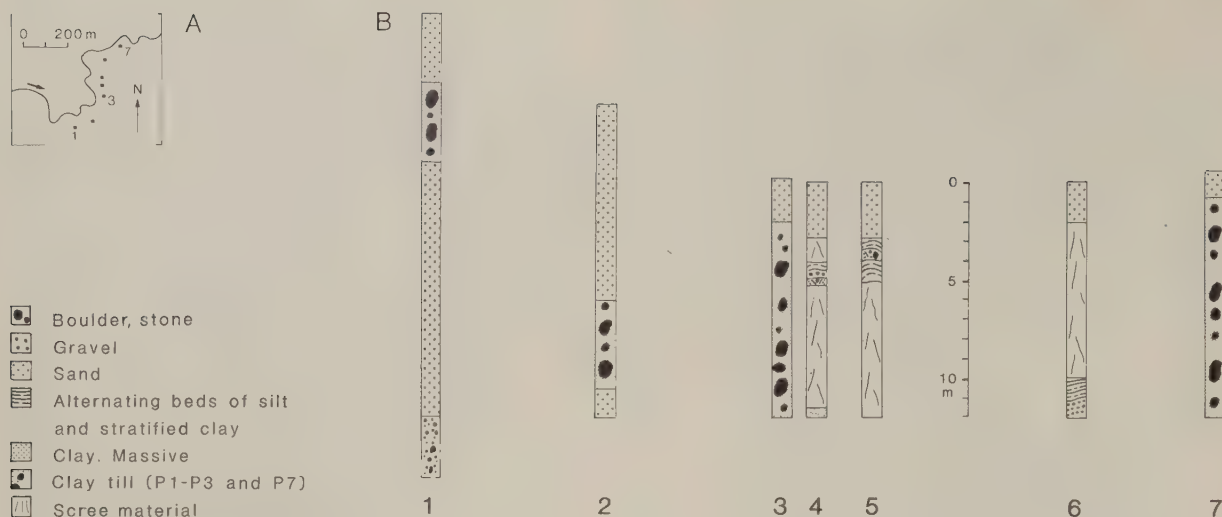


Fig. 49. The stratigraphy at site 84 in subarea 7E. A. The location of the stratigraphic profiles. B. The stratigraphic profiles. The base of the profiles are located at the same level as Julebodaån Stream, except for profile 1, the lowermost part of which is based on a bore log. Profiles 1-3 and 7 are according to G. De Geer (1889a).

before the advance and excludes the possibility that the till was deposited by drop beneath a floating ice sheet.

5.7.6 Subarea 7F

General description

In subarea 7F (Fig. 50), G. De Geer (1889a) distinguished four stratigraphic units: the lower till, the lower sand, the upper till and the upper sand. I make use of De Geer's stratigraphic division in the description of the glacial deposits in subarea 7F below. The area north and west of Ravlunda was remapped in order to obtain a more detailed picture of the extent of the upper till.

The lower till - The lower till is exposed on the southern and northern valley sides. It is up to 20 m thick. According to G. De Geer (1889a), the lower till is made up of clayey till or clay till on the southern valley side. However, a 4 m deep excavation (site 87) and several about 1 m deep excavations here show that the till is mainly sandy or clayey. On the northern valley side, the lower till is sandy. Well bore logs indicate that it consists of clayey till or clay till below the stratified drift in the central part of the valley.

The lower sand - The lower sand is exposed in the western part of subarea 7F. It is up to 30 m thick in the area north of Ravlunda and well bore log 43 (Fig. 50C) suggests that east-southeast of Ravlunda, it is 60 m thick. The lower sand is dissected by the Verkaån Stream and several brooks. The surface of the lower sand reaches about 50 m a.s.l. in the westernmost part of subarea 7F, slopes from here toward the east and reaches about 30 m a.s.l. in the area where it becomes covered by the upper till. Paleocurrent analyses show that the upper part of the lower sand was deposited by meltwater currents from the west. Two of these analyses (sites 105 and 113) were made in exposures where the lower sand is overlaid by the upper till. The lower sand contains beds of

silt with laminae of clay and beds of varved clay.

The upper till - The upper till is found in the eastern part of the valley in subarea 7F and is mainly less than 3 m thick. In the area east of Ravlunda, the westernmost extent of the till is indicated by the dashed line in Fig. 50. In the area northeast of Ravlunda, the exact extent of the upper till is uncertain. The surface of the till slopes toward the east in the eastern part of subarea 7F and at the coast-line it is indicated by concentrations of boulders. Brown and massive clay till makes up the upper till. The stone and boulder content is low.

The upper sand - The upper sand occurs in the eastern part of subarea 7F and is up to 15 m thick. The surface of the sand is located at about 25 m a.s.l. The sand makes up accumulations with a gently undulating surface or forms mounds and hummocks with intervening depressions. The latter is especially the case around Vitemölla.

Exposures and post-auger logs

The logs below are described from the ground surface and downward.

Site 87 - Excavation in till (Fig. 61) described in Chapter 5.10.4.

Site 88 - Post-auger log. 0-0.4 m: Top-soil. 0.4-2.9 m: Fine and medium sand with laminae of clay.

Site 89 - Post-auger log. 0-0.4 m: Top-soil. 0.4-1.0 m: Medium sand. 1.0-1.2 m: Laminated clay. 1.2-1.8 m: Medium sand with clay laminae.

Site 90 - Post-auger log. 0-0.5 m: Top-soil. 0.5-0.8 m: Silt. 0.8-2.0 m: Clayey silt.

Site 91 - Post-auger log. 0-0.4 m: Top-soil. 0.4-0.8 m: Clay. 0.8-2.0 m: Medium sand with laminae of clay.

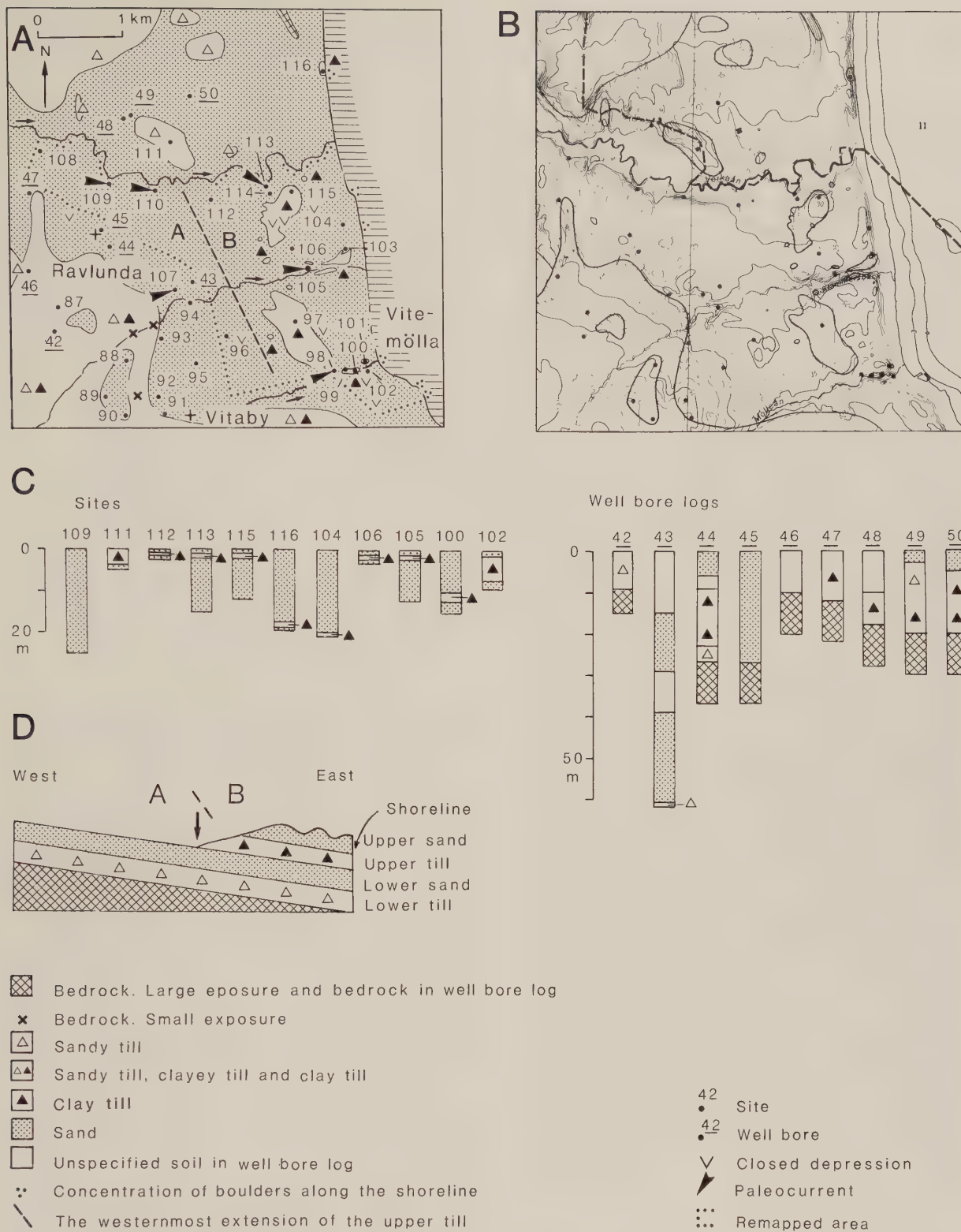


Fig. 50. Subarea 7F. A. Geology. B. Morphology. The contour interval is 5 m. The boundaries between different types of drift as well as the location of sites and well bores are indicated. The paleocurrent analyses show the flow direction prevailing when the upper part of the lower sand accumulated (Fig. 50D). C. Sites and well bore logs. D. The stratigraphy in subarea 7F in an east-west trending profile located in the central part of the valley.

Site 92 - Post-auger log. 0-0.4 m: Top-soil.
0.4-2.1 m: Sand with laminae of clay.

Site 93 - Marl-pit in laminated clayey sand

(G. De Geer, SGU archiv, Uppsala).

Site 94 - Small exposure displaying horizontal laminae and thin beds of sand and silt.

Site 95 - Post-auger log. 0-0.3 m: Top-soil. 0.3-1.0 m: Silt. 1.0-1.6 m: Sandy silt. 1.6-1.9 m: Silt.

Site 96 - Post-auger log. 0-0.4 m: Top-soil. 0.4-1.7 m: Silt. 1.7-2.7 m: Clayey silt.

Site 97 - Post-auger log. 0-0.3 m: Top-soil. 0.3-0.9 m: Clayey silt and silty clay. 0.9-1.7 m: Till clay consisting of massive clay with some stones and gravel (Appendix 2: L73).

Site 98 - A 10 m long and 5 m high exposure at a stream, largely covered by scree. Cleaned surfaces display medium and fine sand with some silt. Ripple lamination (xy plane: type A, yz plane: troughs, xz plane: lunate rib lamination) indicates a paleocurrent from 250°.

Site 99 - An exposure at a stream, in which the following log was registered.

0.1-1 m: Brown, massive clay till with low stone and boulder content.

1.1-2.0 m: Scree.

2.0-3.3 m: In the upper part of the bed a grey, clayey and poorly-sorted material with stones and some boulders occurs. It contains short and irregular beds of faintly-laminated sand with short beds of clayey and poorly-sorted material containing gravel and stones.

3.3-5.0 m: Laminated sand and silt. The lamination is folded in the upper part of the bed and horizontal in the lower part.

Site 100 - A 100 m long exposure at a stream, largely covered by scree and vegetation. Four logs were registered (Fig. 51: L2-L5). The distance between log 2 and log 3 is 50 m and between logs 3-5, 25 m. Where only small exposed surfaces occurred, it was not possible to register sedimentary structures.

Profile 2: 0-5.6 m: Sand. 5.6-8.1 m: Gravelly sand. 8.1-9.0 m: Sand. 9.0-10.2 m: Brown, massive clay till with some stones and boulders 10.2-10.9 m: Varved clay which grades downward into laminated fine sand and silt. 10.9-13.0 m: Sand with flat lamination. 13.0-13.5 m: Silt with laminae of clay. 13.5-14.0 m: Greyish clayey till with low boulder and stone content (Appendix 2: L74).

Profile 3: 0-5.0 m: Sand. 5.0-10.0 m: Gravelly sand with some stones. 10.0-12.0 m: Brown, massive clay till with low stone content. Two boulders were observed. Glacial striae and crescentic fractures were found on one of the boulders. 12.0-15.0 m: Irregularly-folded laminae of fine sand, silt and clay.

Profile 4: 0-2.0 m: Brown, massive clay till with a low stone and boulder content. 2.0-5.0 m: Sand.

Profile 5: 0-0.6 m: Stony gravel. 0.6-5.0 m: Irregularly-folded strata of sand and silt.

Site 101 - A 3 m long and 3 m high exposure displaying brown, massive clay till with some stones (Appendix 2: L75).

Site 102 - An exposure at a stream in which G. De Geer (1889a) registered the following log: 0-1.0 m: Sand and gravel. 1.0-7.1 m: Grey clay till. 7.1-7.3 m: Laminated clay. 7.3-9.3 m: Sand.

Site 103 - Post-auger log. 0-0.4 m: Top-soil. 0.4-1.5 m: Sand. 1.5-1.6 m: Brown massive clay till containing small amounts of gravel. 1.6-1.7 m: Sand.

Site 104 - A 10 m long and 20 m high exposure showing sand.

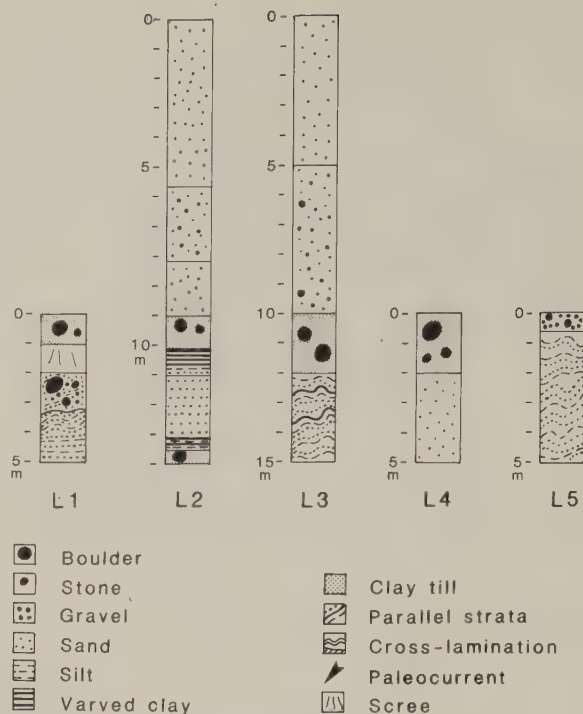


Fig. 51. Logs registered at site 99 (L1) and site 100 (L2-L5) in subarea 7F.

Site 105 - A 50 m long and 10 m high exposure parts of which are covered by scree. The following log was registered (Fig. 52):

0-0.8 m: Scree.

0.8-1.7 m: Brown, massive clay till with some stones (Appendix 2: L76).

1.7-2.6 m: Medium sand with ripple lamination (xy plane: type B, yz plane: troughs and wavy parallel lamination) indicating a paleocurrent from 270°.

2.6-4.5 m: Sand, largely covered by scree.

4.5-5.5 m: Sand with flat lamination.

5.4-7.2 m: Sand, largely covered by scree.

7.2-8.5 m: Medium sand with ripple lamination (xy plane: type A and B, yz plane: troughs) indicating a paleocurrent from 270°.

8.5-10.5 m: Alternating beds of coarse sand with trough cross-lamination, medium and fine sand with ripple lamination and silt with clay laminae. The ripple lamination (xy-plane: type A, yz plane: troughs) indicates a paleocurrent from 270°.

Site 106 - Post-auger log. 0-0.4 m: Top-soil. 0.4-1.1 m: Brown, massive clay till with low stone content (Appendix 2: L78).

Site 107 - A 50 m long and 15 m high exposure at a brook. The exposure is largely covered by scree. Cleaned surfaces display ripple laminated sand with beds of silt. The ripple lamination (xy plane: type B, yz plane troughs) indicates a paleocurrent from 250°.

Site 108 - A 50x25 m large and 5 m deep sand-pit, the walls of which are largely covered by scree. Gravelly sand occurs in the lower part of the walls and sand in the upper part.

Site 109 - A 50 m long and 25 m high exposure at the Verkaan Stream in part covered by scree. The following log was registered

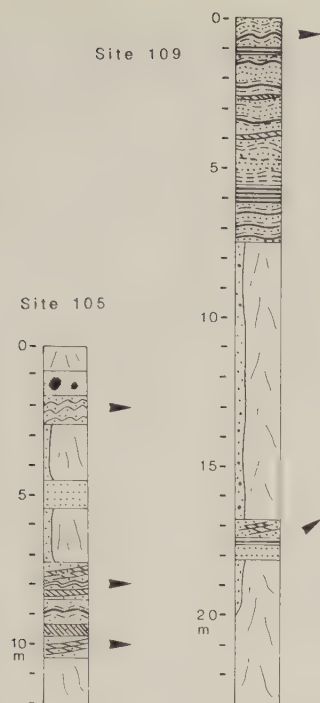


Fig. 52. Logs registered at sites 105 and 109 in subarea 7F. The legend is the same as in Fig. 51.

(Fig. 52):

0-1.0 m: Fine sand and silt with clay laminae. Ripple lamination (xy-plane: type A, yz-plane: wavy parallel lamination) in the fine sand indicates a paleocurrent from 270°.

1.0-1.2 m: Varved clay.

1.2-5.6 m: Sand with thin beds and laminae of silt. Clay laminae occur in the silt.

5.6-6.2 m: Varved clay. Laminae of reddish brown clay and 1-2 cm thick beds of grey silty clay alternate. Sixteen varves were registered.

6.2-7.5 m: Laminae and 1-2 cm thick beds of clay alternating with silt, fine sand and medium sand.

7.5-16.7 m: Sand and gravelly sand largely covered by scree.

16.7-17.4 m: Fine and medium sand with ripple lamination (xy-plane: type A, yz-plane: troughs) indicating a paleocurrent from 276°.

17.4-17.6 m: Clay with diffuse lamination.

17.6-18.1 m: Fine-gravelly sand with flat lamination (Appendix 2: L79).

18.1-25.0 m: Sand, largely covered by scree.

Site 110 - A 3 m long and 3 m high exposure at the Verkaän Stream showing horizontally-bedded sand with some silt beds. Ripple lamination in the sand (xy plane: type A, yz plane: troughs) indicates a paleocurrent from 280°.

Site 111 - Exposure in which the following log was registered by G. De Geer (1889a): 0-3.5 m: Yellow clayey till or clay till. 3.5-4.0 m: Folded sand with clay laminae.

Site 112 - Post-auger log. 0-0.4 m: Top-soil. 0.4-0.6 m: Sand. 0.6-1.0 m: Brown, massive clay till containing a small amount of gravel. 1.0-1.7 m: Gravelly sand.

Site 113 - A 100 m long and 5-17 m high exposure at the Verkaän Stream. The exposure is largely covered by scree. Exposed surfaces showed a 16 m thick bed of sand, parts of which are overlaid by an up to 1 m thick bed of brown, massive clay till (Appendix 2: L81). Cleaned surfaces show that flat lamination and ripple lamination occur in the sand. The ripple lamination (xy plane: type A, yz plane troughs) indicates a paleocurrent from 300°.

Site 114 - A 1x1 m large and 0.9 m deep excavation displaying a 0.5 m thick bed of brown, massive clay till underlain by sand with flat lamination and cross-lamination.

Site 115 - Post-auger log. 0-0.3 m: Top-soil. 0.3-0.6 m: Sand. 0.6-2.6 m: Brown, massive clay till with low stone content (Appendix 2: L84). 2.6-2.9 m: Sand. 2.9-3.1 m: Silt. About 20 m west of the bore, an exposure shows that the till is underlain by at least 10 m of sand.

Site 116 - A 150 m long and 20 m high exposure in a beach cliff, largely covered by scree and vegetation. An up to 3 m thick bed of brown and grey, massive clay till with low stone and boulder content was observed at the base of the cliff (Appendix 2: L85). The till bed is overlaid by an about 15 m thick bed of sand and parts of the till bed rest on sand.

Discussion

The genesis of the lower till is discussed in Chapter 5.10.4.

The grain-size composition of the lower sand indicates deposition in standing water.

The upper till must have been deposited during an advance of the ice sheet, since the lower sand accumulated in standing water and the upper sand indicates that the till has been overlaid by glacier ice. It is not possible that the lower sand accumulated beneath a floating ice sheet and the upper till by dropping of englacial drift from the ice sheet, as the lower sand does not contain beds of till, and beds of sand have not been observed in the upper till. This conclusion is supported by the eastward-flowing currents which deposited the sand making up the upper part of the lower sand.

The upper sand is mainly a glaciofluvial sediment which accumulated in contact with stagnant glacier ice, since the sand often forms mounds, hummocks and closed depressions. The eastward-sloping surface of the upper till indicates that the sedimentation of the sand took place close to the margin of the ice sheet. It is likely that parts of the upper sand are beach deposits (T. Nilsson 1961).

5.8 Area 8. The S:t Olof area

The glacial striae and the glaciofluvial deposits shown in Fig. 53 have been mapped by Daniel (in prep.). Bedrock exposures and the distribution of sandy till, clayey till and clay till is based on the maps by G. De Geer (1889a), Holst (1892) and Munthe, Johansson & Grönwall (1920).

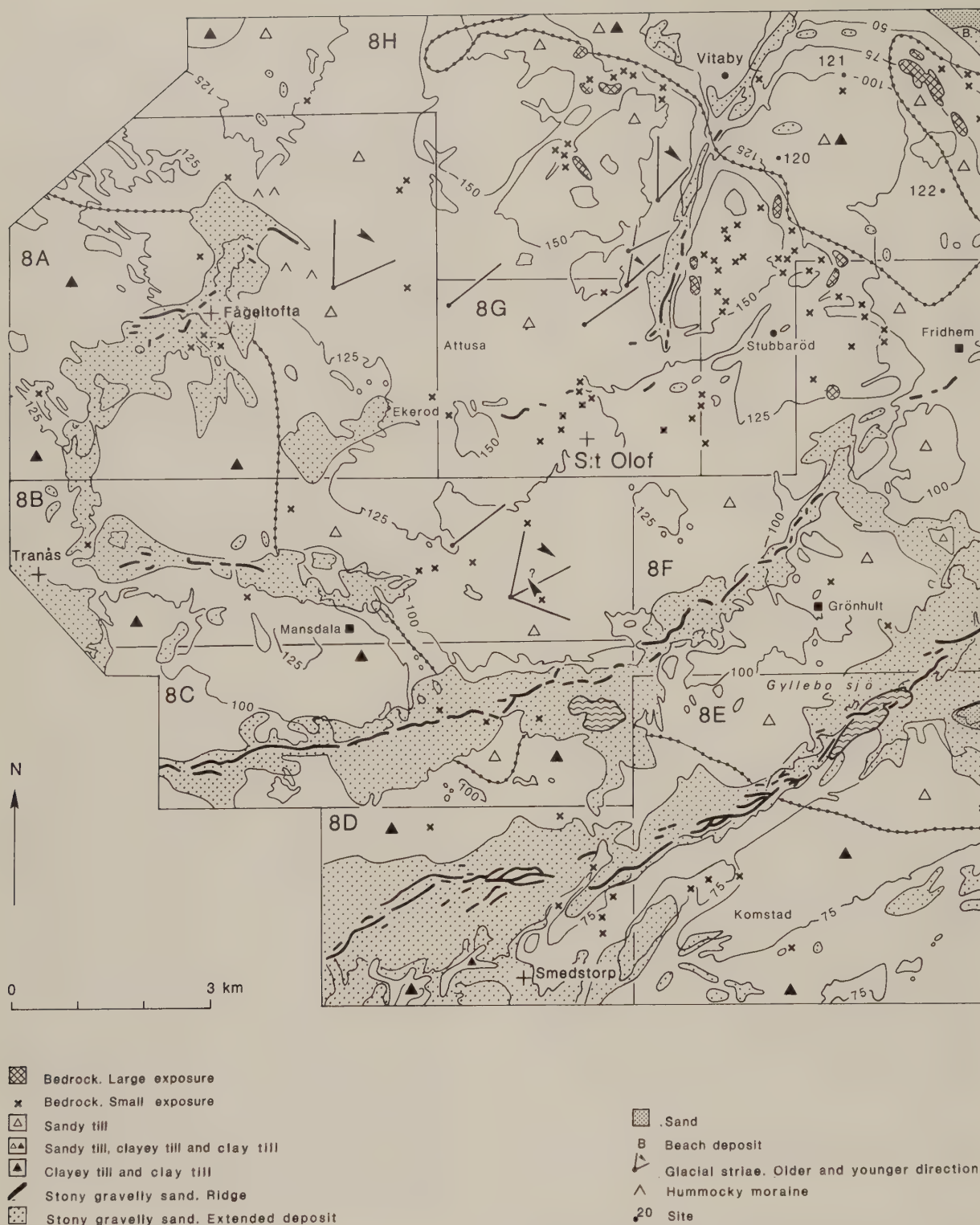


Fig. 53. The geology and morphology in area 8, the S:t Olof area. The contour interval is 25 m.

5.8.1 Description

General

In the greater part of area 8, the surface of the Linderödsåsen horst slopes toward the southwest (Fig. 53). The surface is located 100–175 m a.s.l. in the area west and south of Vitaby in subarea 8H and 75–100 m a.s.l. in the southwestern part of area 8. In the

northeastern part of area 8, the surface of the horst slopes toward the northeast. The valleys and depressions occurring between the heights in area 8 are of varying width and mainly less than 25 m deep. However, up to 40 m deep valleys are found in the area south of Vitaby. The valleys and depressions trend between the northwest-southeast and the east-west.

Precambrian gneiss, Cambrian and Ordo-

vician alum shale, Ordovician limestone, Ordovician shale and Silurian shale make up the bedrock. The alum shale, shale and limestone are found below the clayey till and clay till in the southwestern part of the area and north of Fågeltofta. Sandstone is found between the alum shale and shale in the southwestern part of area 8 and a northwest-south-east trending line crossing S:t Olof. Northeast of this line, gneiss makes up the bedrock.

The majority of the glacial striae indicate an ice movement from the northeast. In the central and northern parts of area 8, an older ice movement from the north is registered. At a site located 2.5 km south-southwest of S:t Olof, striae indicating an ice movement from the east-southeast occur. The age relation between these and the other striae found here is uncertain (Daniel in prep.).

The till forms mainly a cover reflecting the irregularities of the bedrock surface. As stated above, the clayey till and clay till in the southern and western parts of the area are underlaid by shale and alum shale. The sandy till in the central and northern parts of area 8 rests on sandstone, gneiss and gneissic granite. The sandy till, clayey till and clay till in the area around Vitaby is underlaid by gneiss.

The glaciofluvial deposits form zones trending between the north-northeast - south-southwest the east-west. The deposits are mainly made up of stony gravelly sand, but sand also occurs (Rydenheim 1973; Daniel in prep.). The stratified drift makes up ridges, mounds, hummocks and accumulations with a gently undulating surface. The ridges are often winding. They are up to 1.5 km long and as much as 100 m wide and 15 m high (Rydenheim 1973; Daniel in prep.). The mounds, hummocks and accumulations with a gently undulating surface form up to 3 km wide zones surrounding the ridges of stratified drift.

The relation between the glaciofluvial deposits and the morphology of the landscape is described in the following sections.

The relation between the morphology of the landscape and the glaciofluvial deposits in area 8

Subarea 8A - The western zone with glaciofluvial deposits in subarea 8A trends roughly northeast-southwest (Fig. 54). The surface of the deposits is situated 115-130 m a.s.l. north of Fågeltofta, the deposits are found in an about 1 km wide and less than 15 m deep depression. In the northern part of subarea 8A, the floor of the depression slopes toward the north. Here the depression becomes wider and continues in area 7.

South of Fågeltofta, the western branch of the zone is situated on the western slope of a shallow and wide depression, the floor of which slopes toward the south. The eastern branch is located in the deepest part of this depression.

The eastern zone with glaciofluvial deposits trends roughly east-northeast - west-southwest. It is found in the prolongation of the ridges of stratified drift in subarea 8G (Fig. 53). At Ekeröd, the deposits are located in a shallow depression.

Subarea 8B - The glaciofluvial deposits in subarea 8B form mainly an east-west trending zone. The deposits reach 130 m a.s.l. in the western part of the subarea, 100 m a.s.l. in the eastern part of the subarea and are

located between less than 40 m high heights (Fig. 54). Except for in the area immediately west of Mansdala, the ground surface slopes toward the south along the zone with glaciofluvial deposits.

Subarea 8C - The stratified drift in subarea 8C (Fig. 54) forms an east-northeast - west-southwest trending zone which is situated in the lowermost part of a 2.5-3.5 km wide depression. South of the zone, the till-covered heights rise less than 20 m above the glaciofluvial deposits, and, in the north, 35 m above the deposits. The surface of the deposits reaches 85-105 m a.s.l.

Subarea 8D - The till and bedrock surface underlying the glaciofluvial deposits in subarea 8D has a southward-sloping surface (Fig. 54). The surface of the deposits reaches about 90 m a.s.l. in the north and 75 m a.s.l. in the south. The zone with ridges of stratified drift trends east-northeast - west-southwest and is located 80-85 m a.s.l.

Subarea 8E - At and immediately southwest of Lake Gyllebo sjö, the northeast-southwest trending zone with ridges of stratified drift is located in a 0.5-1 km wide and 15-30 m deep valley with a southwestward-sloping floor (Fig. 53). The valley is indicated by the 75 m contour line in Fig. 53. About 2 km north of Komstad, the zone with ridges is found on the northern side of the valley and northwest of Komstad, north of it. The extended deposits of stratified drift surrounding the ridges are situated mainly on the northern side of the valley and north of it. Glaciofluvial and fluvial erosion account for the fact that the stratified drift is mainly absent in the bottom of the valley southwest of Lake Gyllebo sjö. The valley becomes wider in the northeastern part of subarea 8E and is here occupied by a 2.5 km wide zone with stratified drift continuing in subarea 8F and in area 9 (Plate 1).

Subarea 8F - The northeast-southwest trending zone with glaciofluvial deposits that is situated southwest of Fridhem is located between till-covered heights in the area west and north of Grönhult (Fig. 54). Southeast of the zone, the heights rise 5-15 m above the surface of the glaciofluvial deposits and immediately northwest of the zone, 5-10 m. Further to the northwest, heights rise up to 30 m above the surface of the stratified drift. In the area north-northeast of Grönhult, the stratified drift is located in a 500 m wide and up to 30 m deep depression, the floor of which slopes toward the east-northeast. In the southern part of subarea 8F, the surface of the glaciofluvial deposits is located around 90 m a.s.l.; west of Grönhult, around 105 m a.s.l. and south of Fridhem, around 80 m a.s.l.

The zone with stratified drift northeast of Grönhult is situated in the lowermost part of a northwest-southeast trending depression with a southeastward-sloping floor. The depression is up to 1.5 km wide and 25 m deep.

The glaciofluvial deposits in the area east of Grönhult are located in a depression that continues in area 9 (Plate 1).

Subarea 8G - The east-northeast - west-southwest trending zone with glaciofluvial deposits northwest of S:t Olof is situated in a 400 m wide and less than 10 m deep depression with an eastward-sloping floor (Fig. 54). The depression continues east of the zone with stratified drift and becomes wider in the area northeast of S:t Olof. Glaciofluvial deposits

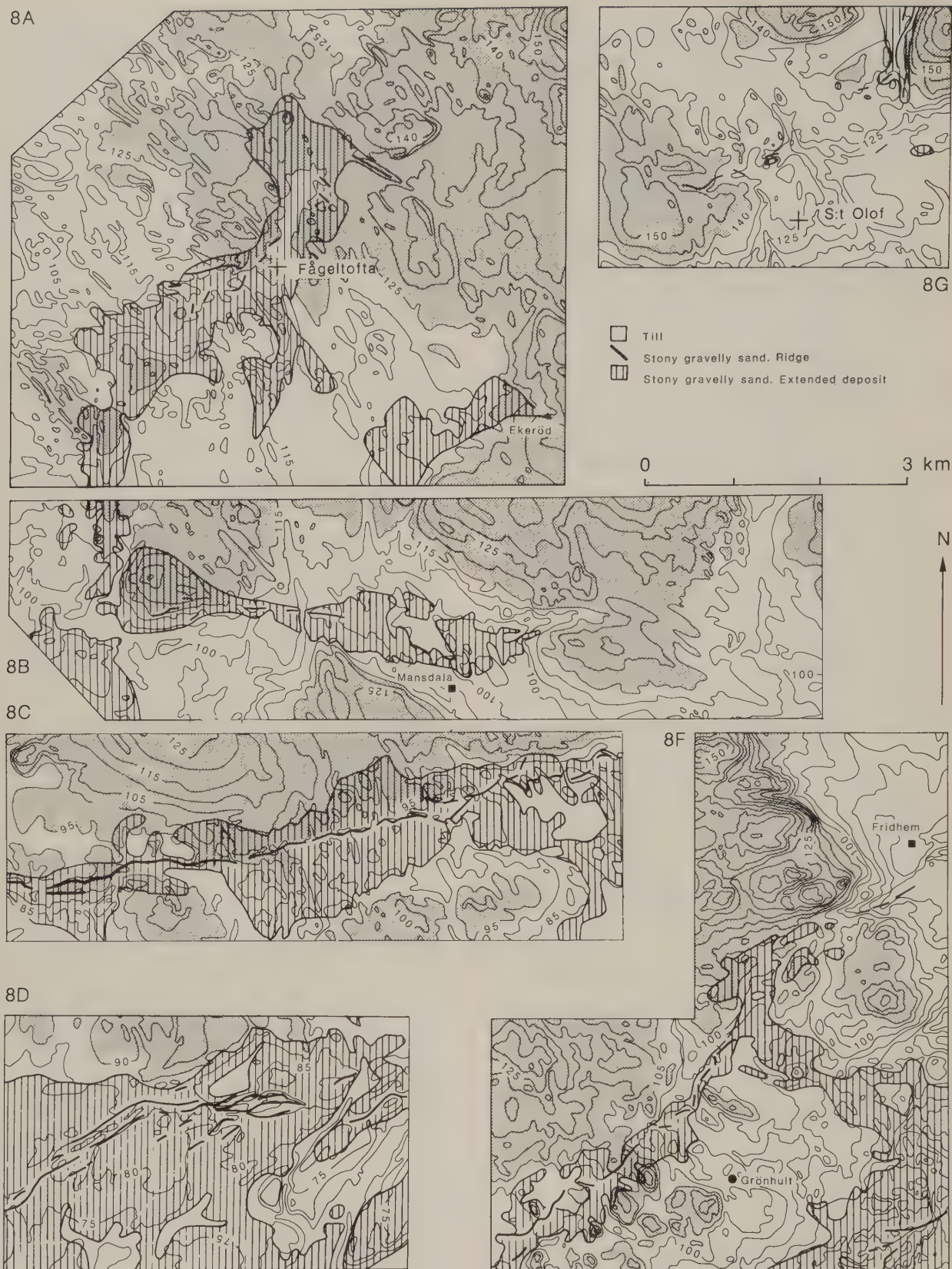


Fig. 54. The relation between the morphology of the landscape and the glaciofluvial deposits in subareas 8A-8D, 8G and 8F. The location of the subareas is indicated in Fig. 53.

are also found here.

The north-south trending zone with stratified drift in the northeastern part of subarea

8G is found in the prolongation of a valley in subarea 8H (Fig. 53).

Subarea 8H - The north-northeast - south-southwest trending zone with stratified drift at Vitaby is situated in the central and deepest part of a 1 km wide and 25-40 m deep valley (Fig. 53). The floor of the valley reaches 130 m a.s.l. at the boundary between subareas 8G and 8H and 50 m a.s.l. 1 km northeast of Vitaby.

The glaciofluvial deposits west-northwest and east-southeast of Vitaby are situated in an area with a gently undulating ground surface.

Exposures

Sites 120-122 - Excavations in till (Fig. 61) described in Chapter 5.10.4.

5.8.2 Discussion

The glaciofluvial deposits in area 8 are located in valleys and depressions or in their prolongations. Since the valleys and depressions are mainly less than 25 m deep, the meltwater which transported the glaciofluvial sediments must have flowed at the base of the ice sheet in contact with the underlying till or bedrock (cf. Chapter 5.6.4). From the above and from the morphology of the valleys and depressions, it follows that in parts of area 8, the meltwater flowed in an up-slope direction. Thus, the part of the ice sheet beneath which the meltwater flowed had a sloping surface. This is also indicated by the zones with glaciofluvial deposits southwest of Fågeltofta (subarea 8A) and west of Mansdala (subarea 8B) and by the zone with ridges in subarea 8D, since these zones are not situated in the absolute low-points of the areas. If the meltwater flow was not controlled by an ice sheet with a sloping surface, it would have flowed in the absolute low-points of these areas.

The glaciofluvial sediments making up ridges must have accumulated directly on till or bedrock, since the ridges indicate well-defined meltwater conduits (cf. Chapter 5.6.4) and the meltwater flowed at the base of the ice sheet. As the ridges indicate well-defined meltwater conduits and their morphology shows no signs of disturbance by active ice, they were formed in non-disintegrated and stagnant glacier ice.

The sediments making up the hummocky parts of the extended deposits of stratified drift ought at least to some extent to have been underlain by glacier ice. The ice must have been thin, however, since otherwise the location of the extended deposits would not have been controlled by the shallow valleys and depressions in area 8 (cf. Chapter 5.6.4). From this, from the width of the zones with extended deposits and from the fact that the sediments were transported by subglacially-flowing meltwater streams, one can conclude that the sedimentation took place in connection with disintegrating glacier ice.

In parts of subareas 8A, 8C, 8F and 8H, the surface of the zones with extended deposits of stratified drift slopes toward the northeast or the east. The surface must have sloped in the same directions during the deposition of the sediments, as the location of the extended deposits is controlled by the valleys and depressions in area 8. The deposition, therefore, took place by gradual stages, since meltwater cannot flow in an up-slope direction in disintegrating glacier ice. Thus, the ice sheet disintegrated by gradual stages in area 8. This is also indicated by the

extended deposits southwest of Fågeltofta in subarea 8A and in the northern part of subarea 8D. The location of these deposits can only be explained if the part of the ice sheet in which the sediment-transporting meltwater flowed was non-disintegrated and had a sloping surface.

The irregular morphology and low relief in subareas 8A-8D and in the southern part of subarea 8G cannot have controlled the main flow direction of the subglacial meltwater, which means that the direction of slope of the ice surface is indicated by the trend of the zones with ridges of stratified drift occurring here. Consequently, during the recession of the ice sheet, the ice surface sloped toward the south-southwest around Fågeltofta in subarea 8A, toward the west in subarea 8B and toward the west-southwest in subareas 8C, 8D and 8G.

The ice sheet was mainly at the pressure melting point at least at the base during the recession in area 8, since by then subglacial meltwater occurred.

5.9 Area 9. The Rörum area

The information in Fig. 55A is based on the geological map by Daniel (in prep.).

5.9.1 General description

In the central part of area 9, a depression occurs (Fig. 55). It is located in the continuation of a northeast-southwest trending valley in area 8 (Fig. 53 and 56). The depression immediately west of the boundary between area 8 and area 9 is about 2 km wide and 10 m deep. It is about 5 km wide and 50 m deep in the area east of Rörum. The bedrock surface in the depression slopes toward a direction between the east and the northeast. A fault is located along the northern ice-contact slope south-southeast of Rörum. The fault is indicated by the step-formed longitudinal bottom profile of the ravines occurring here. Along the coast-line north and south of the depression, the slope of the horst is steep and 50-100 m high. North and south of the depression, the top surface of the horst is mainly gently undulating. Shallow depressions are situated in the southern part of area 9 and an about 40 m deep valley is found at S. Mellby.

Precambrian gneiss, Cambrian sandstone, Cambrian and Ordovician alum shale, Ordovician shale, Ordovician limestone and Silurian shale make up the bedrock (Fig. 57). Gneiss is found beneath the till east and north of Rörum. Sandstone, alum shale, shale and limestone are exposed along the coast-line northwest of Stenshuvud. Alum shale and shale are found beneath the sand east of Rörum and beneath the clayey till and clay till in the south-western part of area 9. Alum shale outcrops along the coast-line in the southeasternmost part of the area. In the rest of area 9, sandstone makes up the bedrock.

The majority of the glacial striae indicate an ice movement from the northeast. An older movement from the north is suggested by striae west of Stenshuvud. In the southeasternmost part of area 8, glacial striae and crescentic fractures indicate easterly and southerly ice movement directions. The age relation between the individual directions has not been made completely clear (Daniel in prep.).

The till forms a cover reflecting the irregu-



Fig. 55. Area 9, the Rörum area. A. Geology. B. Morphology. The contour interval is 25 m. Areas above 75 m a.s.l. are shaded. Glacial striae and ridges of stratified drift are indicated.

larities of the underlying bedrock surface. Sandy till, clayey till and clay till resting on gneiss occur in the northern part of area 9. The sandy till in the southern part of the area is overlaid by gneiss and sandstone. As stated above, the clayey till and clay till in the southwestern part of area 9 rest on alum shale and shale.

The glaciofluvial deposits are mainly located in the depression in the central part of area 9. They are made up of sand and stony gravelly sand. Paleocurrent analyses show that the accumulation took place by meltwater currents from between the east and the northeast (Daniel in prep.). The glaciofluvial deposits are described at length in Chapter 5.9.2.

Varved clay overlies the stratified drift

in the area around Rörum. The surface of the clay reaches 15–30 m a.s.l. west of Rörum.

Beach deposits of stony gravelly sand occur at and northwest of Stenshuvud and southeast of Baskemölla. Northwest of Stenshuvud, beach ridges are common and the deposits reach up to 32.3 m a.s.l. (G. De Geer 1889a). The Topographical Map indicates that the deposits southeast of Baskemölla reach up to 20–25 m a.s.l. Along the coast-line, the till and stratified drift is overlaid by beach sand.

5.9.2 Glaciofluvial deposits

The zone with sand south of Ö. Vemmerlöv is situated on the eastern slope of a north-south

trending depression with a southward-sloping floor. The depression is about 1.5 km wide and 15 m deep. Between Karlaby and Rosdala, the sand is located in an east-northeast - west-southwest trending depression that is 1 km wide and about 10 m deep. The deposits of sand in the area east of Karlaby are surrounded by till with a gently undulating surface. The deposits of sand described above form mounds or accumulations with a gently undulating surface.

The stony gravelly sand in the area north and west of Ö. Vemmerlöv forms mounds and hummocks between which are found closed depressions. A winding, northeast-southwest trending ridge of stony gravelly sand occurs 1 km east of Ö. Vemmerlöv. It has a triangular cross-section, is 500 m long, up to 25 m wide and is 2-4 m high. The surface of the stony gravelly sand is situated 60-75 m a.s.l.

Mounds, hummocks, a ridge and closed depressions constitute the morphological elements of the stony gravelly sand south and west of Forse. South of Forse and in the area around and east of Lake Gyllebo sjö, the surface of the deposits is largely situated at about 70 m a.s.l. (Fig. 56).

South of Rörum, a body of sand that is bounded by ice-contact slopes occurs. The surface of the sand, which is mainly located 80-90 m a.s.l., rises 20-25 m above the surface of the stony gravelly sand in the south and the west and 15-35 m above the sand northeast of the northern ice-contact slope. The sand between the ice-contact slopes it has a level or gently undulating surface where it is not dissected by streams or brooks. Some closed depressions also occur.

The north-south trending zone with sand at S. Mellby is situated in the valley occurring here.

5.9.3 Discussion

The stratified drift in the area around and south of Rörum accumulated in standing water, since it is made up of sand. Sedimentation in standing water is also indicated by the fact that the sand is overlaid by varved clay around Rörum. Further, the sand forms a large continuous body which is located in a depression. In the south and the west, the depression is surrounded by stony gravelly sand with a hummocky relief. This difference in morphology and grain-size composition, can only be explained if meltwater was ponded in the depression and the ice sheet calved here.

The surface of the ponded water ought to have reached about 85 m a.s.l. when the sand surrounded by ice-contact slopes accumulated. This can be concluded since the sand surface is horizontal and the underlying till or bedrock surface slopes toward the northeast. If the sedimentation of the sand was not restricted by a water surface, the surface of the sand would have sloped toward the northeast. The absence of a bed of stony gravelly sand overlying the sand and reflecting the fluvial conditions that ought to have prevailed when the basin was filled with sand can be explained by burying of stones and gravel close to the margin of the ice sheet.

The surface of the sand in the depression is located 10-25 m above the surface of the glacial deposits south and west of the depression. This means that stagnant glacier ice remained in the latter areas when the sand accumulated. The stony gravelly sand in these areas was deposited before the sand in the



Fig. 56. The relation between the glaciofluvial deposits in areas 8 and 9. The 75 m contour line is shown and areas above 75 m a.s.l. are shaded. The vertical line in the central part of the figure is the boundary between areas 8 and 9.

depression, since it is not possible that sand was trapped in the depression and stony gravelly sand was transported away from it.

It is likely that the difference in level between the surface of the sand southwest and northeast of the northern ice-contact slope is due to the bedrock fault occurring here.

Since the ridge 1 km east of Ö. Vemmerlöv is situated in an area with a gently undulating ground surface, it follows that the ice surface sloped toward the southwest when the sediments making up the ridge accumulated.

The meltwater which transported the glaciofluvial sediments flowed at the base of an ice sheet with a sloping surface, as the sediments are mainly located in a depression and the meltwater flowed in an up-slope direction here.

The occurrence of subglacial meltwater during the accumulation of the glaciofluvial sediments shows that the ice sheet at least at the base was mainly at the pressure melting point. Further, it is likely that at least in a marginal zone of the ice sheet, all of the ice was at the pressure melting point, as the stratified drift is overlaid by varved clay which indicates that surface meltwater penetrated the ice sheet and was transported at its base (cf. Chapter 5.6.6).

5.10 The lithological composition of the glacial deposits on the central part of the Linderödsåsen horst

5.10.1 The grouping of the rock fragments in the glacial deposits and their provenance

The rock fragments in the glacial deposits on the Linderödsåsen horst have been grouped in the following way (Appendix 2):

- 1) Crystalline rocks
- 2) Red mica quartzite
- 3) Cambrian sandstone
- 4) Shale
- 5) Paleozoic limestone
- 6) Cretaceous limy sandstone, sandy limestone and limestone
- 7) Cretaceous flint
- 8) Other kinds of rocks (Appendix 2: Others)

In most of the samples, the first seven groups comprise more than 97 % of the total amount of rocks in sizes between 3 and 11 mm. The lithology and the provenance of the rocks are described in the following sections, as well as the lithological varieties in the individual rock groups. It was not possible to distinguish between them with same accuracy as between the rocks listed in Appendix 2.

Crystalline rocks

Mainly Precambrian gneiss, gneissic granite and granite make up the crystalline rocks in the lithological samples. A large number of the crystalline rock fragments consist of reddish fine-grained gneiss of the same type that is common on the Linderödsåsen horst. Dolerite and other kinds of basic crystalline rocks are found in all samples but their percentage is low, mainly less than 2 %. Porphyry has been observed, but only in fractions of 1 %. Crystalline rocks of kinds other than the above-described are included in the group 'Other kinds of rocks'.

The bedrock in southern Sweden and in the area around and south of the island of Åland is dominated by Precambrian crystalline rocks (Fig. 58). Porphyry, acid volcanic rocks and metamorphic sedimentary rocks also occur here (Lundegårdh in Lundegårdh et al. 1970).

Red mica quartzite

The mica quartzite that is found in the north-eastern part of Skåne (Fig. 57) consists of flattened quartz grains and mica flakes aligned parallel to each other. It is often rich in mica and the colour varies between white and red. The quartz grains are angular and 0.5–5 mm in diameter. The mica quartzite which is exposed east-northeast and west-southwest of Brösarp (Fig. 60) is white. It is often more coarse-grained and contains less mica than the mica quartzite in the northeastern part of Skåne.

The mica quartzite group comprises only the red mica quartzite which has been ob-

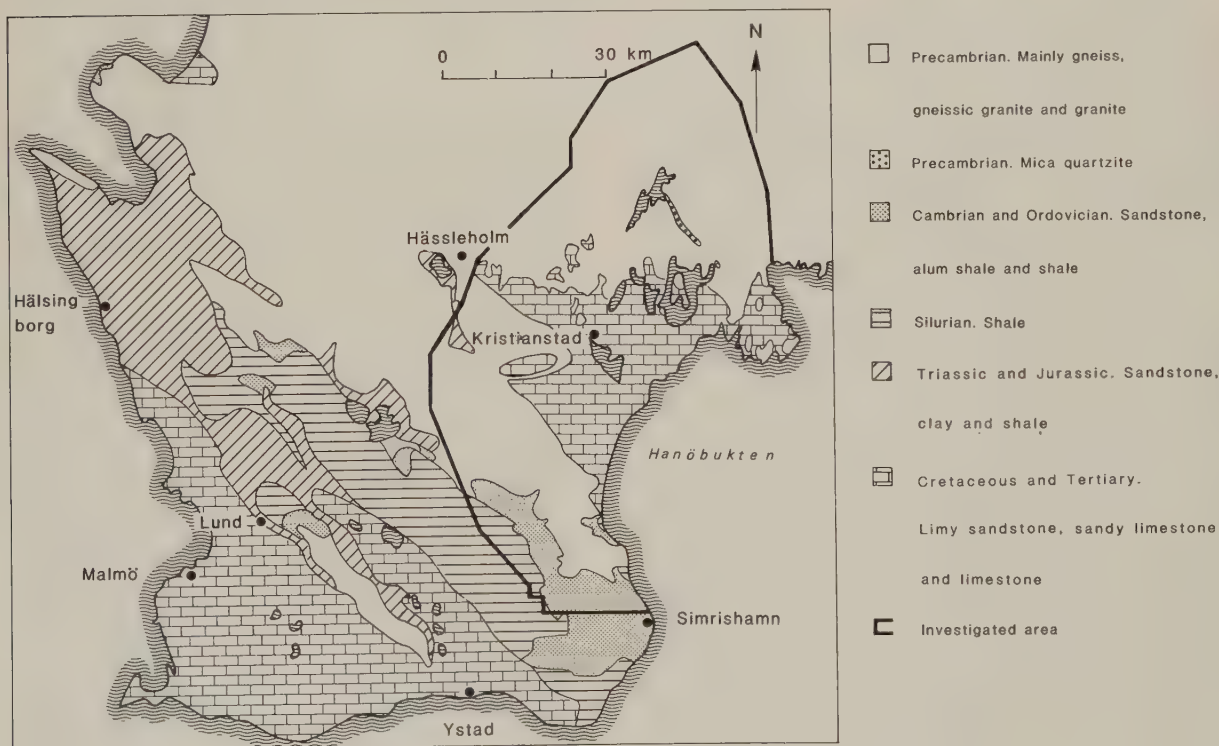


Fig. 57. The bedrock in Skåne simplified according to Kronfält et al. (1978), Bergström & Shaikh (1980, 1982) and Bergström et al. (1982). The extent of the mica quartzite northeast of Kristianstad is according to G. De Geer (1889b) and personal investigations.

served exclusively in the northeastern part of Skåne. White mica quartzite, is included in the group 'Other kinds of rocks'.

Cambrian sandstone

The Cambrian sandstone is a hard quartzitic sandstone made up almost entirely of quartz grains, which mainly are 0.1-1 mm in diameter. The grains are subrounded and the boundaries are mostly clearly visible. Grains of glauconite occur and are especially abundant when the quartz grains are fine-sand sized. The colour of the Cambrian sandstone is white, yellowish white, red or greenish grey. The latter colour is found when a large amount of glauconite is present.

White, yellowish white and greenish grey Cambrian sandstone is found in Skåne (Bergström et al. 1982) and in the Baltic depression (Regnéll in Magnusson et al. 1963). Red Cambrian sandstone is only exposed on the Swedish mainland west of the island of Öland and is indicated in well bore logs from Öland and the island of Gotland (Regnéll in Magnusson et al. 1963). Red Cambrian sandstone is also exposed on the island of Bornholm (Wienberg Rasmussen 1975).

Shale and alum shale

The colour of the shale in the lithological samples varies between light grey and greyish black. The light grey shale is often silty and slightly more coarse-grained than the greyish black shale. The alum shale is greyish black or black and is distinguished from the greyish black shale by producing a glossy streak when scratched with a nail. I have not distinguished between the light grey shale, the greyish black shale and the alum shale in appendix 2 since colour, grain size and amount of organic matter are transitional. However, it can be stated that the amount of light grey and greyish black shale varies in the glacial deposits and that alum shale seldom occurs.

Visual inspection by J. Bergström of the SGU, Lund, showed that most of the greyish black shale in the lithological samples is of Ordovician age and that most of the light grey shale is of Silurian age.

Ordovician and Silurian shale are found in Skåne (Bergström et al. 1982) and on Bornholm (Wienberg Rasmussen 1975). They are not indicated in well bore logs from Öland and Gotland but Silurian shale may occur in the area south-southeast of Öland (Fig. 58).

Palaeozoic limestone

The Palaeozoic limestones are dark grey, light grey or red. They are dense and contain a varying amount of fossil fragments. The transition in colour between the dark and light grey limestones is transitional. They are, therefore, not separated in Appendix 2. However, it can be stated that the dark grey limestone is uncommon in the lithological samples. Visual examination by J. Bergström of the SGU, Lund, showed that the red limestone and most of the grey limestone in the lithological samples are of Ordovician age and that some of the light grey limestone is of Silurian age.

Dark grey Ordovician limestone is found in Skåne (Bergström et al. 1982). On the Linderödsåsen horst, it is exposed at Andrarum (Fig. 59) and southeast of Vitemölla

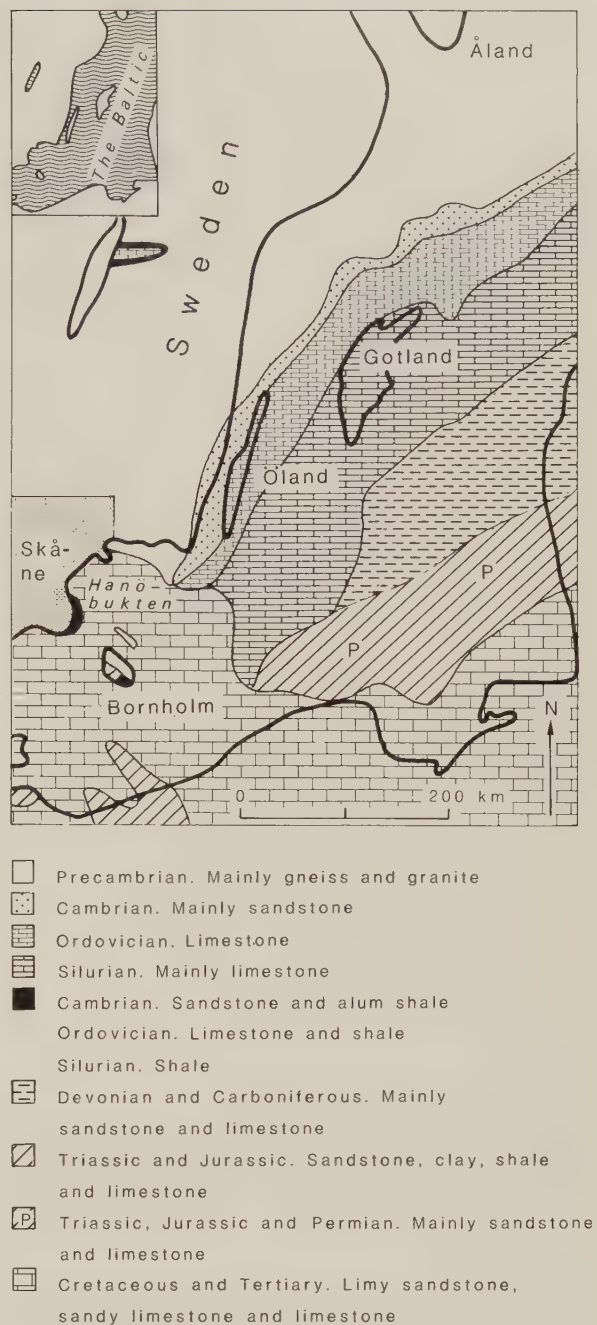


Fig. 58. The bedrock in the Baltic depression and its surroundings except Skåne according to Regnéll (in Magnusson et al. 1963), Lundegårdh & Lindström (in Lundegårdh et al. 1970), Dadlez (1974), Wienberg Rasmussen (1975), Flodén (1977, 1980) and Kumpas (1980).

(Fig. 60). Light grey and red Ordovician limestone are found on Öland and are indicated in well bore logs from Gotland (Regnéll in Magnusson et al. 1963). Fairly dark grey and dark grey Ordovician limestone outcrops on Bornholm (Wienberg Rasmussen 1975, J. Bergström pers. comm.).

Silurian limestone is found on Gotland (Regnéll in Magnusson et al. 1963). Along with associated rocks, it makes up the Silurian bedrock in the Baltic depression.

Cretaceous limy sandstone, sandy limestone and limestone

The Cretaceous limy sandstone, sandy limestone and limestone are made up of varying amounts of quartz grains, macroscopic fossils and fossil fragments and fine-grained lime. Glauconite, which forms either grains or a film on the quartz grains, is also found. The rocks are mainly porous and poorly consolidated.

Limy sandstone, sandy limestone and limestone outcrop on the plains around Kristianstad (Bergström et al. 1982).

Sandstone was observed in two bores in Hanöbukten Bay (Kumpas 1980).

Cretaceous flint

The Cretaceous flint was separated from the other Cretaceous rocks, since it is resistant to weathering. Consequently, it is a useful indicator in weathered glacial deposits. The colour of the flint varies between grey and black.

The provenance is the same as for the above-described Cretaceous rocks.

Other kinds of rocks

This group comprises the following kinds of rocks:

- 1) Crystalline rocks which are not included in the group 'Crystalline rocks'.
- 2) White mica quartzite.
- 3) Sedimentary rocks not belonging to the groups listed in Appendix 2.
- 4) Rocks which were difficult to determine due to for example weathering.

5.10.2 The bedrock in the areas around Maglehem and Brösarp

Parts of the bedrock in the areas around Maglehem and Brösarp are not completely known. They are discussed below on the basis of bedrock exposures and well bore logs (Fig. 60).

Cretaceous rocks are considered to occur in the area east and southeast of Maglehem (Fig. 59) since such rocks have been found in connection with well borings northeast of the horst and occur in Hanöbukten Bay (Kumpas 1980).

Sedimentary rocks may occur in parts of the depression southwest of Maglehem, which is suggested by the seismic profile S3 (Chapter 5.7.3, Figs. 39 and 40). However, well bores 30 and 34 (Fig. 60) indicate that gneiss occurs in the southern and eastern parts of the depression.

If Paleozoic rocks outcrop at all in the central part of the valley between Hallamölla and Brösarp (Fig. 60), they can be composed of Cambrian sandstone only, since this kind of rock is found at Hallamölla and Ravlunda.

The Cambrian sandstone at Brösarp (Fig. 59) is indicated by well bores 44 and 48 (Fig. 60).

Alum shale was found at a depth of 65 m in well bore 43 (Fig. 60) according to E. Mohrén (in T. Nilsson 1961). The well bore is described only to a depth of 61.4 m by the well bore log in the SGU archives at Lund. It is, however, likely that shale or

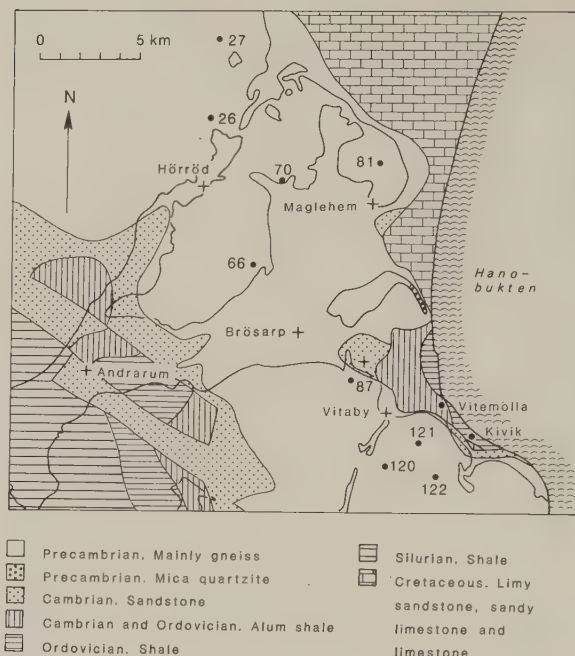


Fig. 59. The bedrock on the central part of the Linderödsåsen horst according to Bergström & Shaikh (1980, 1982). The boundaries between till and stratified drift and sites 26, 27, 66, 70, 81, 87 and 120-122 are indicated (Fig. 61).

alum shale outcrops in this area (Fig. 59), since bedrock of this type is exposed along the coast-line southeast of Vitemölla and Cambrian sandstone is found at Ravlunda.

Silurian shale is considered to outcrop along the coast-line north of Vitemölla (Fig. 59), since Silurian shale is exposed southeast of Vitemölla.

Gneiss constitutes the bedrock below the sandy till, clayey till and clay till in the area southwest of Vitaby (Fig. 60), as gneiss was found at sites 120 and 121 and is exposed in the vicinity of site 121.

Cambrian sandstone, Cambrian and Ordovician alum shale, Ordovician limestone, Ordovician shale and Silurian shale are exposed along the coast-line southeast of Vitemölla (Fig. 60).

The Palaeozoic rocks found along the eastern side of the Linderödsåsen horst can at most be exposed some kilometers east of the coast-line, since Cretaceous rocks occur here and in the rest of Hanöbukten Bay (Kumpas 1980).

5.10.3 The stratigraphy of the glacial deposits

The stratigraphical division of the glacial deposits on the central part of the Linderödsåsen horst (Fig. 60) was proposed by G. De Geer (1889a). The lower till denotes the sandy till, clayey till and clay till which are exposed on the heights of the horst. In the valleys and depressions, the lower till is overlaid by stratified drift, called the lower sand. Southeast of Maglehem and east of Ravlunda, a bed of clay till rests on the upper sand. De Geer named it the upper till. Parts of the upper till are overlaid by stratified drift and beach deposits, which are denoted the upper sand.

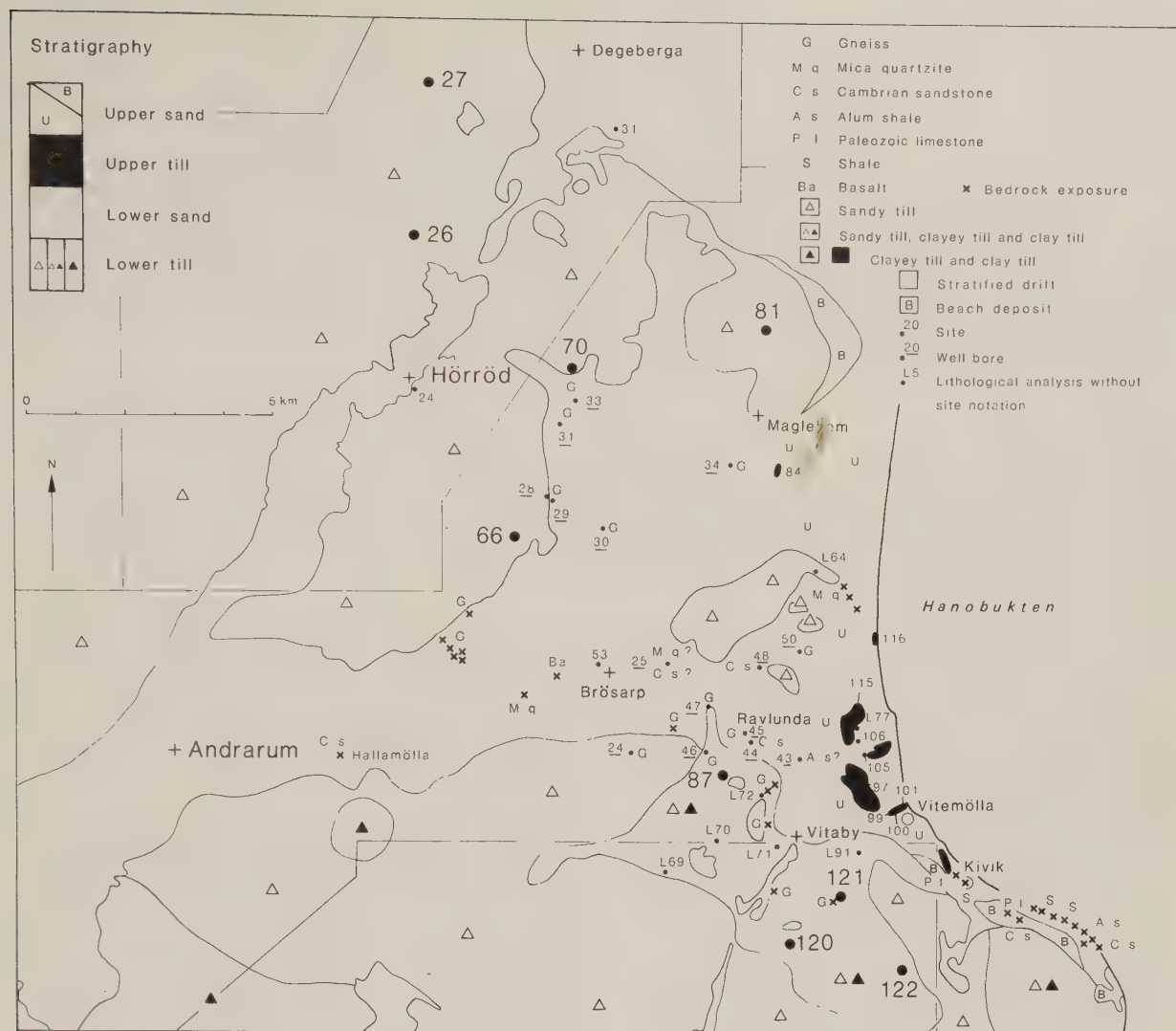


Fig. 60. Lithological analyses in the till on the central part of the Linderödsåsen horst. The boundaries between till and stratified drift are indicated. The stratigraphy of the glacial deposits is shown in the upper left corner of the figure. Bedrock exposures and bedrock indicated in well bore logs of importance to the discussion of the not completely known bedrock in the areas around Maglehem and Brösarp are shown. Figure 60 covers the same area as Fig. 59.

5.10.4 The lower till

Grain-size composition

The lower till has been investigated in nine excavations, named site 26, 27, 66, 70, 81, 87 and 120-122 (Figs. 60 and 61). The till rests here on gneiss (Fig. 59). The excavations were 5x1 m large and 4-5 m deep. They revealed that the lower till to a depth of about 5 m below the ground surface is made up of sandy till, clayey till and clay till (Fig. 61, Appendix 1). The till is massive and the stone and boulder content is low to moderate. Stones and boulders are angular to subangular. The sandy till is yellow, the clayey till is grey or greyish yellow and the clay till is brown or grey. The observed boundaries between tills of different grain-size composition are horizontal and well-defined. At site 120 (Fig. 61), the boulder, stone and gravel content increases downward in the till. Boulders, stones and gravel are composed almost entirely of reddish gneiss. Fractured bedrock of reddish gneiss with an

irregular surface was observed in the bottom of the excavation. Irregular bodies of brown, massive clay till (Fig. 61: G24) were observed in the sandy and clayey till occurring here.

Lithological composition

Table 1, which is based on the table in Appendix 2, shows that Cambrian sandstone, shale, Palaeozoic limestone and Cretaceous rocks occur in the lower till, although crystalline rocks dominate. A small amount of red mica quartzite also occurs (Appendix 2).

Inspection in the field of stones and boulders as well as the lithological analyses in sizes 3-11 mm reveal that a large part of the crystalline rocks in the lower till consists of local reddish gneiss. However, it was not possible to distinguish between the local gneiss and the non-local crystalline rocks with the same accuracy as between the rock types listed in Appendix 2.

The shale in the lower till is usually greyish black (Ordovician shale) but light

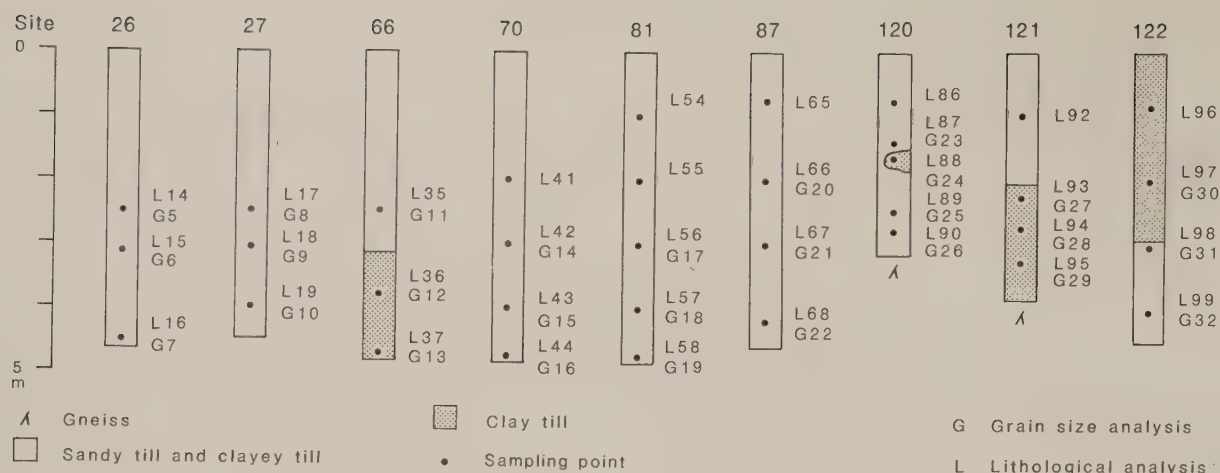


Fig. 61. Lithological analyses and grain-size analyses in the lower till. The location of the sites is shown in Figs. 59 and 60. The grain-size analyses and the lithological analyses are listed in Appendix 1 and 2 respectively.

Table 1. Sedimentary rocks in the lower till for sizes 3-4 mm. Lithological analyses with site notation are indicated in Fig. 61. The location of the sites and analyses without site notation are shown in Fig. 60. The sites are listed from the north toward the south. Cam. sast. = Cambrian Sandstone. Pal. lst. = Palaeozoic limestone. Cret. l. sast., sa. lst. and lst. = Cretaceous limy sandstone, sandy limestone and limestone. Cret. flint. = Crataceous flint.

Site	Sample	Cam. sast. Total/Red %	Shale and alum-shale %	Pal. lst. Total/Red %	Cret. l. sast. sa. lst. and lst. %	Cret. flint %
▼ 27	17	1.6/-	—	—	0.5	0.6
27	18	2.2/0.2	—	0.7/-	2.9	0.2
27	19	1.1/-	—	0.9/-	3.2	0.9
+ 26	14	0.8/-	—	—	0.5	—
26	15	1.1/-	—	1.5/0.4	3.1	0.2
26	16	0.7/-	—	0.2/-	0.4	0.6
■ 70	41	0.5/-	—	—	0.5	0.6
70	42	3.4/0.5	0.3	5.5/1.8	10.8	0.5
70	43	1.2/-	0.2	0.7/-	1.4	0.2
70	44	4.3/0.7	0.3	4.3/0.6	5.8	0.6
* 81	54	4.8/1.1	0.4	—	0.9	0.4
81	55	4.0/0.4	0.6	2.2/0.4	2.0	0.6
81	56	6.5/-	0.4	0.5/0.2	2.2	1.1
81	57	5.9/0.1	—	7.1/0.4	10.3	0.9
81	58	4.0/-	0.9	7.8/1.6	8.5	0.6
△ 66	35	3.0/0.2	—	—	1.5	0.2
66	36	3.8/-	0.5	7.3/0.7	5.8	1.5
66	37	2.3/-	—	5.2/0.4	9.5	1.3
• 87	65	5.6/0.5	0.8	0.2/-	0.7	1.5
87	66	4.9/0.2	1.1	—	0.5	1.3
87	67	6.0/0.8	—	—	1.1	1.0
87	68	3.4/-	0.4	0.4/-	0.9	1.3
● 120	86	2.7/-	9.3	—	0.4	0.8
120	87	3.5/0.4	8.5	—	0.1	0.8
120	88	1.4/0.2	2.7	—	0.7	1.0
120	89	0.2/-	0.3	—	—	—
120	90	—	—	—	—	—
* 121	92	6.2/0.3	1.5	—	0.3	0.3
121	93	4.4/0.4	0.8	—	0.2	1.1
121	94	2.2/0.2	25.1	—	0.2	0.3
121	95	2.0/-	21.9	—	0.3	—
* 122	96	9.8/0.6	2.0	—	0.6	0.4
122	97	6.9/0.5	27.1	2.1/-	0.8	0.1
122	98	5.7/0.4	6.2	8.9/0.9	6.2	0.7
122	99	3.3/0.3	5.3	3.8/0.8	7.4	0.5
69	3.6/-	1.0	—	—	0.2	—
70	8.7/1.1	0.4	—	—	0.6	1.3
71	7.1/0.2	0.2	—	—	0.5	0.2
72	0.5/-	8.3	—	—	0.2	0.2
91	5.6/0.9	0.8	—	—	0.8	1.9

grey shale is also found (Silurian shale). Alum shale is infrequent.

The content of Palaeozoic limestone and Cretaceous limy rocks is lower between 0.5 and 2 m below the ground surface than deeper down in the till (Fig. 62). This is probably due to weathering, which is indicated by two facts.

Firstly, the rock fragments are often weathered close to the ground surface, which is most easily seen when the sampling depth is less than 1 m. In the crystalline rock fragments, especially the feldspar is influenced close to the ground surface and the weathered rock fragments disintegrate rather easily. The shale is usually more soft in samples taken close to the ground surface than at greater depths. The weathered Palaeozoic limestone is soft and only the most resistant parts remain. To a varying degree, the CaCO₃ is dissolved in the limy sandstone and sandy limestone when the sampling depth is small.

Secondly, only the percentage of the easily-weathered limestones decreases toward the ground surface. The sandstone, shale and flint, which are resistant to weathering, do not do so.

The provenance of the rocks in the lower till

A large part of the crystalline rock fragments in the lower till were eroded on the Linderöds-åsen horst.

The provenance of the red mica quartzite is uncertain. Red mica quartzite, which has been found to outcrop in the northeastern part of Skåne, has only been observed in the till at sites 27, 81 and 120 (Fig. 60). The percentage varies between 0.1 and 0.39 % (Appendix 2: samples 19, 57 and 83). Although red mica quartzite has not been observed in the area covered by Fig. 60, it may outcrop here, since most of the bedrock is covered by glacial deposits in this area and since white mica quartzite is exposed here.

The provenance of the red Cambrian sandstone, the red Ordovician limestone, the light grey Ordovician limestone and the Silurian limestone in the lower till must be the Baltic depression around Öland and Gotland (Fig. 58). This can be deduced, since these kinds of rocks outcrop here, are not found in Skåne

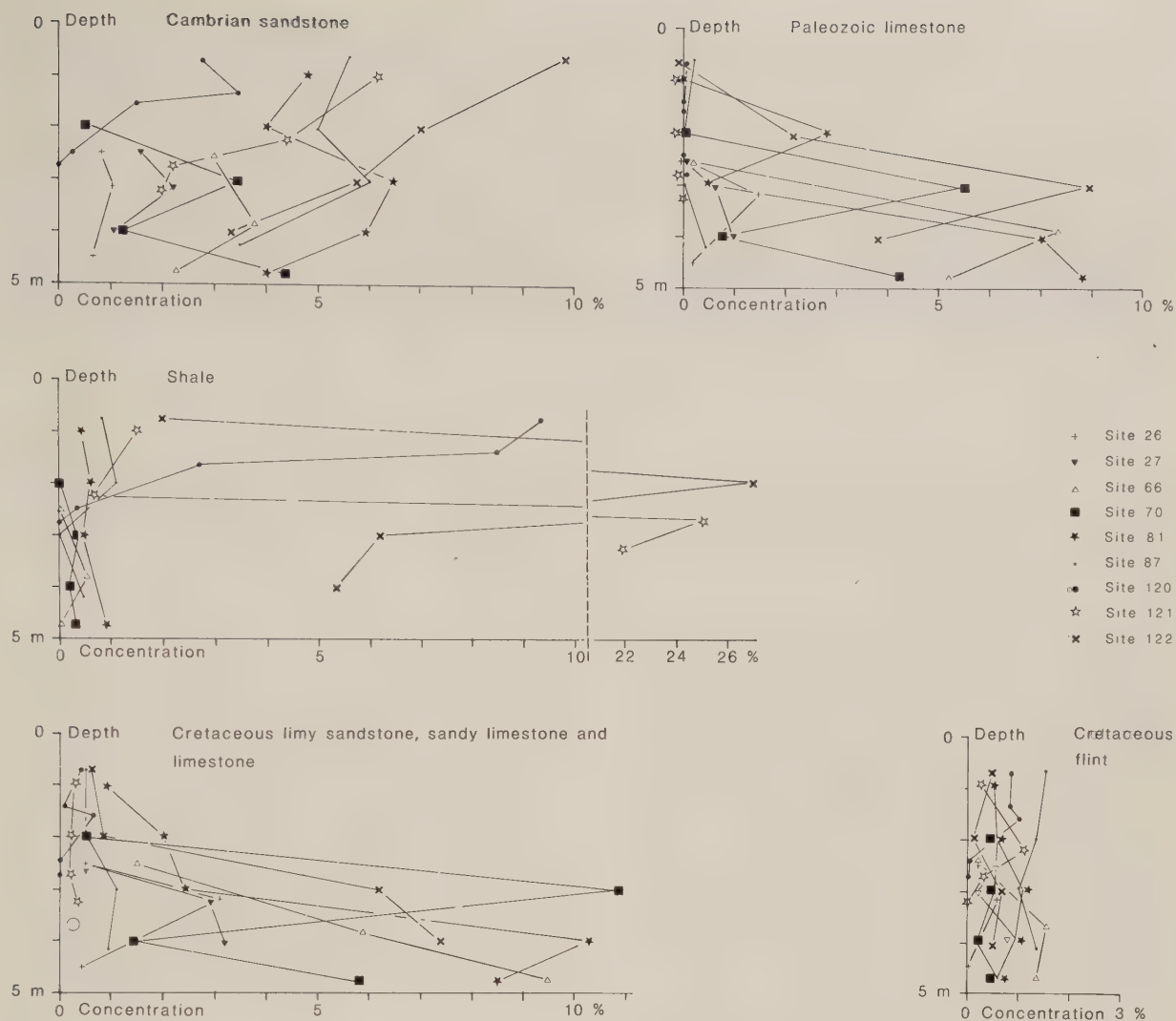


Fig. 62. The percentage of sedimentary rocks in the lower till versus depth below the ground surface.

and since red Ordovician limestone and Silurian limestone do not occur on Bornholm.

The white, yellowish white and greenish grey Cambrian sandstone can have been derived both from the local bedrock and bedrock outside the investigated area. However, a high percentage of these types of Cambrian sandstone corresponds to a high percentage of red Cambrian sandstone and other long-transported rock fragments. Thus, it is likely that also a large part of the white, yellowish white and greenish sandstone is derived from the area around Öland.

The dark grey Ordovician limestone fragments are probably from the local bedrock, since this type of rock is exposed southeast of Vitaby and is not found in the area around Öland and Gotland.

A high percentage of Ordovician shale is found in the lower till at sites 120-122 (Fig. 60, Table 1), which are located in the area southwest of Vitaby. At the rest of the sites, only a small amount occurs. Since the percentage of long-transported rock fragments is not so high or varying and Ordovician shale outcrops southeast of Vitemölla, it follows that the shale is locally eroded. Except along the coast-line, the only possible provenance of the shale is in the area north of Vitemölla.

The provenance of the Cretaceous rock frag-

ments is the plain around Kristianstad (Fig. 57) or Hanöbukten Bay (Fig. 58).

The genesis of the lower till

The Cambrian sandstone, Palaeozoic limestone, shale and Cretaceous rocks are thoroughly mixed with the crystalline rock fragments in the lower till (Fig. 62). The crystalline rock fragments are mainly made up of gneiss. This can only be explained by the following model of deposition for the lower till (Fig. 63). The ice sheet was active, melted at the base and eroded the gneiss bedrock on the horst. Due to the basal melting, the gneiss fragments were deposited after a short transport distance. The englacially-transported sedimentary rocks were released at the base of the ice sheet by the basal melting and accumulated along with the gneiss. By the gradual deposition of the debris, a till consisting of a mixture of gneiss and more long-transported sedimentary rock fragments resulted.

5.10.5 The upper till

Table 2, which is based on the table in Appendix 2, shows that Cambrian sandstone,

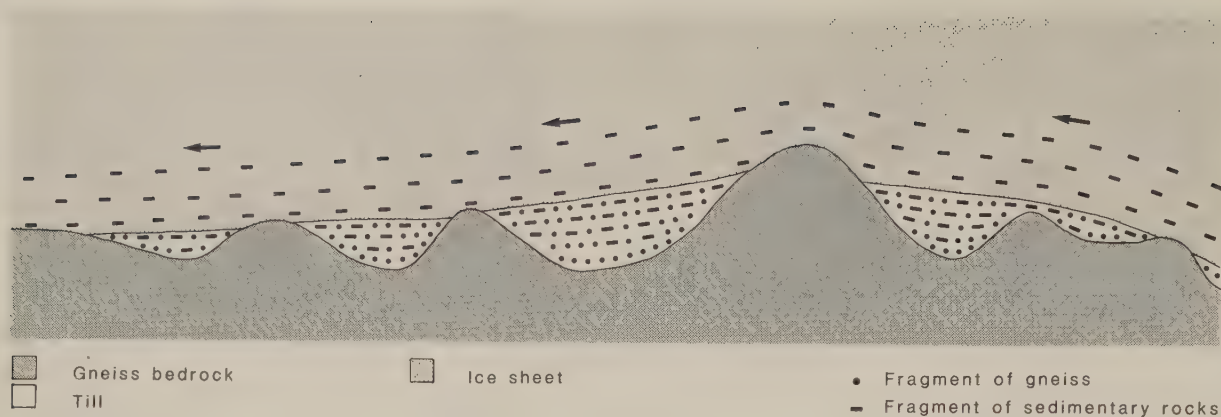


Fig. 63. A model for the deposition of the lower till. The ice sheet was active and eroded the gneiss bedrock. The gneiss fragments were transported close to the base of the ice sheet and were mainly deposited after a short transport distance. The sedimentary rocks were transported englacially and were released from the ice sheet by basal melting. By this they became mixed with the gneiss.

shale, Palaeozoic limestone and Cretaceous rocks are found in the upper till.

Boulders belonging to the upper till are found along the coast-line (Fig. 50). They are made up of crystalline rocks, but not of the reddish gneiss that is found on the Linderödsåsen horst.

The shale in the upper till is mostly light grey, i.e., it is of Silurian age. Alum shale was not observed.

Sample L77 (Fig. 60) was taken 0.8 m below the ground surface. The shale and the crystalline rock fragments in this sample are weathered and only less than 1 % of Palaeozoic limestone is not contained. Sample L78 (site 106) was taken 1.8 m below the ground surface. It contains 25 % Palaeozoic limestone and the crystalline rock fragments are not weathered. Since the distance between the sampling points is only 200 m, it is likely that the upper till is weathered close to the ground surface.

The provenance of the Cambrian sandstone, Palaeozoic limestone and Cretaceous rocks was discussed in the preceding section.

The provenance of the Silurian shale may be in the area south of Öland (Fig. 58) or in the area along the coast-line north of Vitemölla (Fig. 59). The latter is possible since Silurian shale is exposed southeast of Vitemölla (Fig. 60). It is not likely that the shale was eroded southeast of Vitemölla, as then alum shale ought to be contained in the upper till as well.

Table 3 shows that the percentage of Palaeozoic limestone is higher and that the percentage of Cretaceous rocks is lower in the upper till than in the lower till. The table is based on unweathered lithological samples from the lower till, taken 3-5 m below the ground surface and on all samples from the upper till except sample L77, which is weathered.

5.10.6 The lower and upper sand

The lower and upper sand contain sedimentary rocks of the same types as are found in the lower and upper till (Table 4). Greyish black Ordovician shale predominates in the lower sand whereas light grey Silurian shale is most common in the upper sand.

The lithological composition of the lower sand and the lower till are similar (Table 4). The same relation prevails between the upper sand and the upper till. Further, a distinct lithological difference exists between the upper and lower sand.

The lithological composition of the lower till in Table 4 is based on the two lowermost analyses at sites 66, 70 and 81 (Fig. 64).

Table 2. Sedimentary rocks in the upper till for sizes 3-4 mm. The location of the sites is shown in Fig. 60. The sites are listed from the north toward the south. The abbreviations are the same as in Table 1.

Site	Sample	Cam. sst. Total/Red %	Shale and alum-shale %	Pal. lst. Total/Red %	Cret. l. sst. and lst. %	Cret. flint %
84	60	9.1/3.0	10.3	45.0/1.8	0.5	0.3
84	61	11.2/6.9	11.8	31.3/1.0	6.6	1.1
116	85	6.7/1.3	12.6	38.8/2.8	1.5	—
115	84	6.1/2.8	16.3	40.0/1.1	0.8	—
—	77	15.3/3.2	8.2	—	0.6	—
106	78	9.9/4.3	18.7	25.2/1.8	1.5	0.2
105	76	8.7/1.7	11.3	20.9/-	4.3	—
97	73	10.6/3.3	5.9	1.9/-	3.3	—
100	74	5.9/0.6	0.3	6.7/0.3	6.5	0.8
101	75	6.6/1.2	10.2	29.5/1.2	4.4	—

Table 3. The proportions of sedimentary rocks in the lower and upper till for sizes 3-4 mm. The abbreviations are the same as in Table 1.

	Cam. sst.	Shale and alum-shale	Pal. lst.	Cret. l. sst., sa. lst., and flint
Upper till	1	1.46	3.89	0.33
Lower till	1	1.59	0.90	1.34

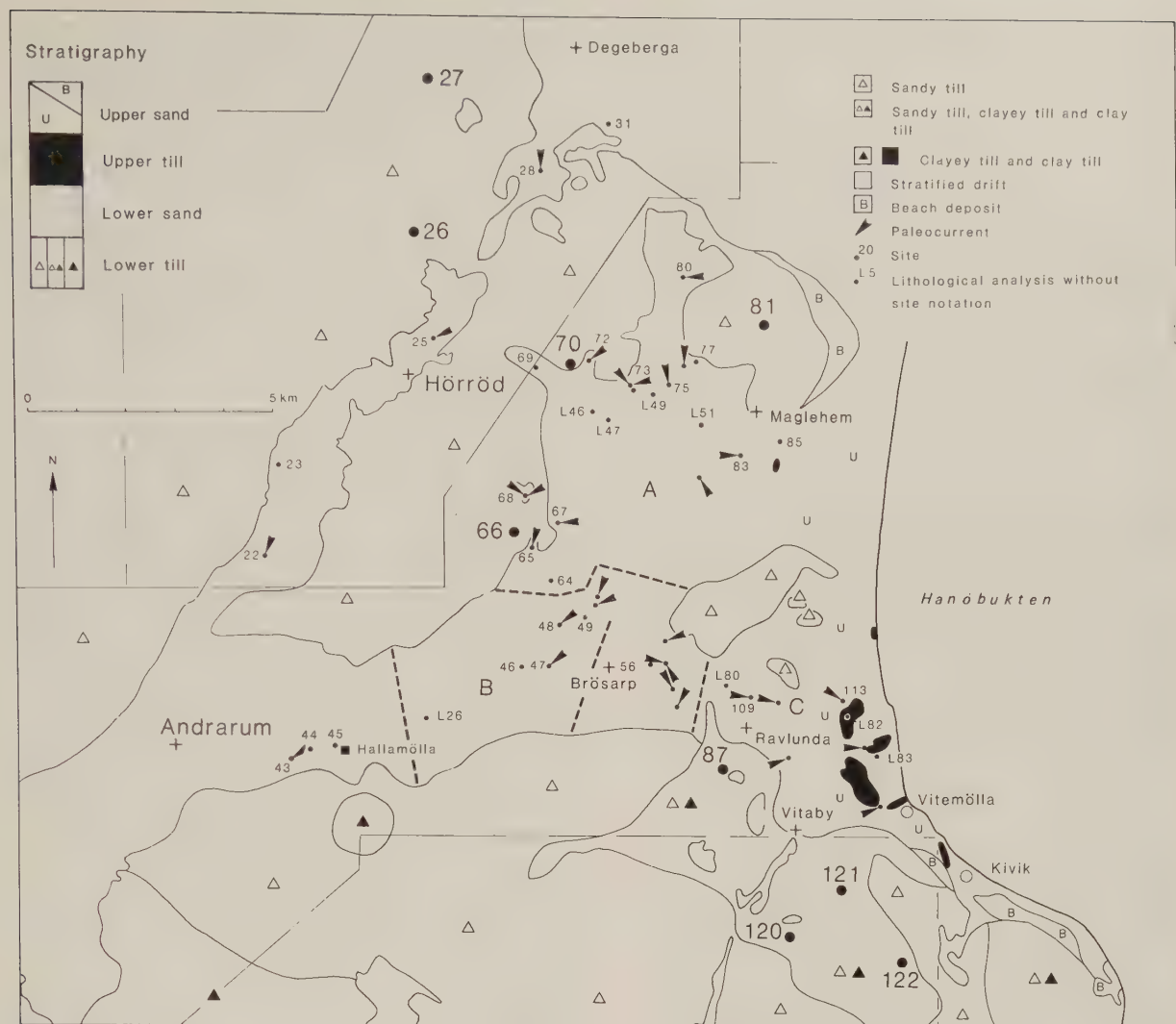


Fig. 64. Lithological analyses and paleocurrent analyses in the stratified drift on the central part of the Linderödsåsen horst. The boundaries between till and stratified drift are indicated. The stratigraphy of the glacial deposits is shown in the upper left corner of the figure. A = Lower sand A. B = Lower sand B. C = Lower sand C. Figure 64 covers the same area as Fig. 59.

Weathering has not taken place at this depth and the sites were selected because a large number of samples were taken in the surrounding lower sand. The lithological composition

Table 4. Comparison between the lithological composition of the lower till, lower sand, upper till and upper sand for sizes 3-4 mm. The abbreviations are the same as in Table 1.

	Cam. sast.	Shale and alum- shale	Pal. lst.	Cret. l. sast., sa. lst., lst. and flint
	%	%	%	%
Upper sand	6.6	11.5	31.9	3.5
Upper till	8.6	12.1	29.1	3.1
Lower sand	4.8	—	4.2	8.6
Lower till	3.6	0.3	5.4	7.7

of the lower sand is based on samples L33, L34, L38-L40, L45-L53 and L59, which were taken in the surroundings of sites 66, 70 and 81. All of the samples from the upper till are included, except for sample L77 which is weathered. The upper sand is only represented by sample L82, since the other two (L62 and L83) were taken in a part of the upper sand that may be a beach deposit. Consequently, they may contain clasts from the lower till. In any case, these two samples display a higher content of Palaeozoic limestone than the lower sand.

In Table 5, lower sand A denotes the sand north of Brösarp (Fig. 64) and lower sand B, the sand in the valley between Hallamölla and Brösarp, which was deposited by meltwater currents from the east. The samples west of Hallamölla are not included, since Cambrian sandstone and alum shale is exposed here.

Lower sand C denotes the sand in the area around and east of Ravlunda, which was deposited by meltwater currents from the west. Table 5 shows that lower sand B con-

Table 5. Variations in the lithological composition of the lower sand for sizes 3-4 mm. The extent of lower sand A, B and C is shown in Fig. 64.

	Cam. sast.	Shale and alum- shale	Pal. lst.	Cret. l. sast., sa. lst., and flint
	%	%	%	%
Lower sand A	4.8	—	4.2	8.6
Lower sand B	8.2	1.7	7.7	5.8
Lower sand C	6.4	1.5	8.4	7.7

tains more Cambrian sandstone, alum shale, shale and Palaeozoic limestone than lower sand A. Along with the paleocurrent analyses, this indicates that lower sand B was deposited by meltwater currents from both the areas north and east of Brösarp. The lithological composition of lower sand B and C are similar. This makes it probable that lower sand C was eroded in the area east of Brösarp, which also is indicated by the morphology in this area.

5.11 The recession of the ice sheet on the southeastern part of the Linderödsåsen horst

I discuss below the recession of the ice sheet on the basis of the glaciofluvial deposits and the glacial striae in parts of areas 6 and 7 and in areas 8 and 9.

5.11.1 The recession of the ice sheet indicated by the glaciofluvial deposits

In parts of areas 6-9, the direction of slope of the ice surface during the recession of the ice sheet is indicated by the trend of the zones with glaciofluvial deposits located in areas with irregular morphology and low relief (Chapters 5.6-5.9). The trend of the boundary between stagnant and active glacier ice is perpendicular to this direction and is indicated by solid lines in Plate 5. I discuss below other indications of the trend of the boundary between stagnant and active glacier ice or the trend of the ice margin where the ice sheet terminated in standing water. These trends are less exact than the above-mentioned and in Plate 5 they are indicated by dashed lines.

Recession line A

The ridge of stratified drift southeast of Hallamölla is located at the mouth of a short, northeast-southwest trending depression (Fig. 37). The meltwater can have been drained through this depression only if the ice surface sloped roughly toward the southwest.

Recession lines B-D

The glaciofluvial sediments between Hallamölla and Brösarp were deposited by meltwater currents from the north and the east (Chapter 5.10.6). This fact indicates that the ice margin trended roughly north-northwest - south-southeast. It is not likely that the ice sheet could have been drained from these two directions if the ice margin trended north-south or east-west. The deposition of the glaciofluvial sediments took place in a lake (Chapter 5.7.2). The surface of the lake reached about 105 m a.s.l., since the surface of the sediments reach up to this level (Fig. 37).

Recession lines E-F

In the area south of Vitaby, valleys and depressions trending between the northwest-southeast and the east-west are found (Chapter 5.8.1). The stratified drift in the valley south-southwest of Vitaby and in the east-west trending depression south of Vitaby (Figs. 53 and 54) suggest that the ice surface sloped roughly toward the southwest, which is indicated by recession line E. If the ice surface had sloped toward the south, it is likely that mainly the valleys and depressions trending around the north-south would have been filled by stratified drift. If, on the other hand, the ice surface sloped toward the west, stratified drift ought to have been found mainly in the valleys and depressions trending around the east-west.

It is probable that the ice surface sloped roughly toward the southwest south of Vitaby, which is indicated by recession line F. If the ice surface sloped toward the west, it is unlikely that accumulation of stratified drift would have taken place in the valley and a southward-sloping ice surface does not fit with recession lines D and I.

Recession line G

The zone with glaciofluvial deposits southeast of S:t Olof is situated between heights (Fig. 54: subarea 8F). Although the heights northeast of the zone may have controlled the main flow direction of the subglacial meltwater to some extent, the trend of the zone indicates that the ice surface sloped roughly toward the southwest.

Recession line H. The glacier-dammed lake at Rörum

Beach deposits are only found below about 30 m a.s.l. in the area around Rörum (Chapter 5.9.1, Fig. 55). Since the deposits are large, they indicate the highest level of a lake with a considerable extent, i.e., the Baltic Ice Lake. Thus, the sand surrounded by ice-contact slopes south of Rörum accumulated in a local glacier-dammed lake, since the surface of the sand reaches mainly 80-90 m a.s.l. This is also indicated by the varved clay around Rörum (Fig. 55). Varved clay is common at about 25 m a.s.l. in the area east of Rörum but has been observed only at two places east of Rörum where the ground surface is located 50-75 m a.s.l. This suggests sedimentation close to the ice margin west of Rörum and at a considerable distance from the ice margin east of Rörum, i.e., in a lake with restricted and large extent respectively.

When the local glacier-dammed lake exist-

ed, the ice margin must have been located southwest of Baskemölla (Fig. 55). Considering that the ice sheet was drained through the depression at Rörum and the recession line at Ö. Vemmerlöv, a roughly northwest-northeast trending ice margin is the most plausible, which is indicated by recession line H in Plate 5.

Recession line I

The glaciofluvial sediments in the area west and southwest of Maglehem accumulated in a lake (Chapters 5.7.3 and 5.7.4). The surface of the sediments is located 100–115 m a.s.l., which indicates that the surface of the lake reached this level. Since the lake was the result of local damming by the ice sheet (see below: Recession line L), it follows that the ice margin was located west of the hill of Stenshuvud when the lake existed. I have drawn the I-line so that the ground surface in the area south of Vitaby is above 110 m a.s.l. west of the line. It is, however, possible that the ice margin was a bit more easterly, as stagnant ice may have occurred in the area around S. Mellby and dammed the lake here (cf. Chapter 5.9.3). In the north, the I-line is based on the extent of stratified drift reaching 100–115 m a.s.l.

Recession line K

The K-line is based on Thuning's (1980) investigations of the recession of the ice sheet in the area around Degeberga (Chapter 5.6.6, Fig. 34).

Recession line L. The glacier-dammed lake in the area north and west of Brösarp

Recession line L is based on the damming and drainage of the glacial lake that existed in the area north and west of Brösarp.

The stratified drift north and east of Brösarp accumulated in a glacial lake. Since the surface of the stratified drift in this area is located 100–115 m a.s.l., the surface of the lake reached about this level. The water was drained toward the west which is indicated by the paleocurrent analyses, recession lines A–D and the erosion channel in which the brook Djurrödsbäcken runs (Chapter 5.7.1, Fig. 36). The channel merges into hummocky stratified drift southeast of Andrarum, which shows that stagnant ice was found here when the lake existed. This explains the fact that the surface of the lake reached 10–25 m above the floor of the erosion channel where it merges into hummocky stratified drift (cf. Chapter 5.9.3). The difference between the floor of the channel and the surface of the lake can also to some extent be explained by the fact that areas close to the ice margin ought to have been more low-lying due to isostatic depression than areas further away. If the area west of Maglehem was pressed down 20 m more than the area southeast of Maglehem, the surface of the lake west of Maglehem, would have reached the same level as the floor of the erosion channel. This would mean a difference in down-pressing of about 20 m per 10 km, which is a realistic value (Andrews 1970; Norddahl 1983).

The sand east of Brösarp was deposited by meltwater currents from the west. This and the lithological composition of the sand (Chapter 5.10.6) indicate that it is redeposit-

ed stratified drift eroded in the area west of Brösarp (Fig. 37). Thus, the lake in which the accumulation of the stratified drift north and west of Brösarp took place was lowered during the recession of the ice sheet. The surface of the sand is located mainly below 35 m a.s.l. Consequently, the ice margin can only have been located east of Stenshuvud during the deposition of the sand, since otherwise a glacier-dammed lake reaching at least 85 m a.s.l. would have existed. This position is indicated by recession line L in Plate 5. The line shows only the approximate westernmost position of the ice margin, which also might have been located further to the east in Hanöbukten Bay. Also the paleocurrent analyses east of Ravlunda indicate that the ice margin was situated in Hanöbukten Bay. If the ice margin was located at or close to the coast-line, glaciofluvial sediments deposited by meltwater currents from the east would have occurred here instead.

Since local damming did not occur when the sand accumulated and the surface of the sand is mainly situated below 50 m a.s.l., it follows that the sedimentation took place mainly in a bay of the lake indicated by the beach deposits northeast of Maglehem and at Stenshuvud. However, the sand reaches up to 50–55 m a.s.l. northeast of Ravlunda. I explain this fact by a gradual lowering of the locally-dammed glacial lake during the recession of the ice sheet. A water surface at 85 m a.s.l. is possible when the ice margin was located east of S. Mellby and at 50 m a.s.l. when the ice margin touched Stenshuvud. A water surface at 85 m a.s.l. ought to have resulted in erosion of the glaciofluvial sediments west of Brösarp, since they reach above this level.

From the discussion above, it follows that the lake which existed in the area north and west of Brösarp resulted from local damming by the ice sheet. The lake indicated by the beach deposits northeast of Maglehem and at Stenshuvud ought to have been the Baltic Ice Lake, since the deposits are as large as the beach deposits on the hill of Ryssberget northeast of Kristianstad and these deposits accumulated along the shore of the Baltic Ice Lake (Chapter 8.4).

Ice-marginal line M

Ice-marginal line M represents the westernmost extent of the ice sheet when it advanced and deposited the upper till (Plate 5, Chapters 5.7.5 and 5.7.6). The extent of the ice sheet northeast of Maglehem is uncertain during the advance. However, the lithological composition of the upper sand in the area west of Maglehem (Chapter 5.10.6) shows that the sand here did not accumulate when the upper till was deposited. The lithological composition also shows that the ice sheet can only have reached less than 1 km east of site 84 south of Maglehem. Further toward the south, the ice sheet reached about 1.5 km east of Ravlunda (Chapter 5.7.6, Fig. 50). In the area southeast of Vitemölla, the exact position of the ice margin is uncertain. However, since the ice sheet only reached a short distance west of the coast-line in the valleys, it is likely that the surrounding heights were not covered by the advancing ice sheet. The area around Rörum was not influenced by the advance, as the upper till has not been observed here.

In the areas around Ravlunda and south of Maglehem, local glacier-dammed lakes may have occurred during the advance of the ice



Fig. 65. The recession of the ice sheet, glacier-dammed lakes and the highest level of the Baltic Ice Lake on the southeastern part of the Linderödsåsen horst.

sheet.

5.11.2 The recession of the ice sheet indicated by glacial striae

In areas 8 and 9, the youngest and most numerous glacial striae indicate an ice movement from the northeast, except for in the area south of Baskemölla (Chapters 5.8.1 and 5.9.1).

The ice sheet receded by gradual stages and had a sloping surface on the southeastern part of the Linderödsåsen horst (Chapters 5.6-5.9). Thus, it was active during the recession except for a zone of stagnant ice which remained in front of the active part of the ice sheet in areas where the deglaciation was

subaerial. From this, one can deduce that the majority of the youngest glacial striae ought to reflect the ice movement direction close to the boundary between stagnant and active glacier ice or close to the ice margin. This is supported by the fact that the direction of slope of the ice surface indicated by the glaciofluvial deposits is parallel to the youngest glacial striae. Thus, the glacial striae in areas 8 and 9 show that the ice sheet here receded toward the northeast, except for in the area south of Baskemölla. The easterly striae occurring here suggest that the ice sheet receded toward the west in this area. The southerly striae may have formed during the same advance which resulted in the upper till in areas 7 and 9 or earlier during the recession of the ice sheet.

5.11.3 Summary

The ice sheet receded toward the east-north-east on the southeastern part of the Linderödsåsen horst (Fig. 65). During the recession, glacier-dammed lakes existed in the areas around Degeberga, Brösarp and Rörum (Fig. 65B and C). When the ice margin was located east of the coast-line, a bay of the Baltic Ice Lake occupied the low-lying areas along

the eastern border of the horst (Fig. 65D). It is not possible to judge how far the ice sheet receded east of the coast-line, and in Fig. 65D only a minimum distance is indicated. During an advance, the ice-sheet covered the low-lying areas east and northeast of Brösarp (Fig. 65E). Also the area south-south-east of Rörum may have been influenced by this advance. If so, a local glacier-dammed lake existed at Rörum instead of a bay of

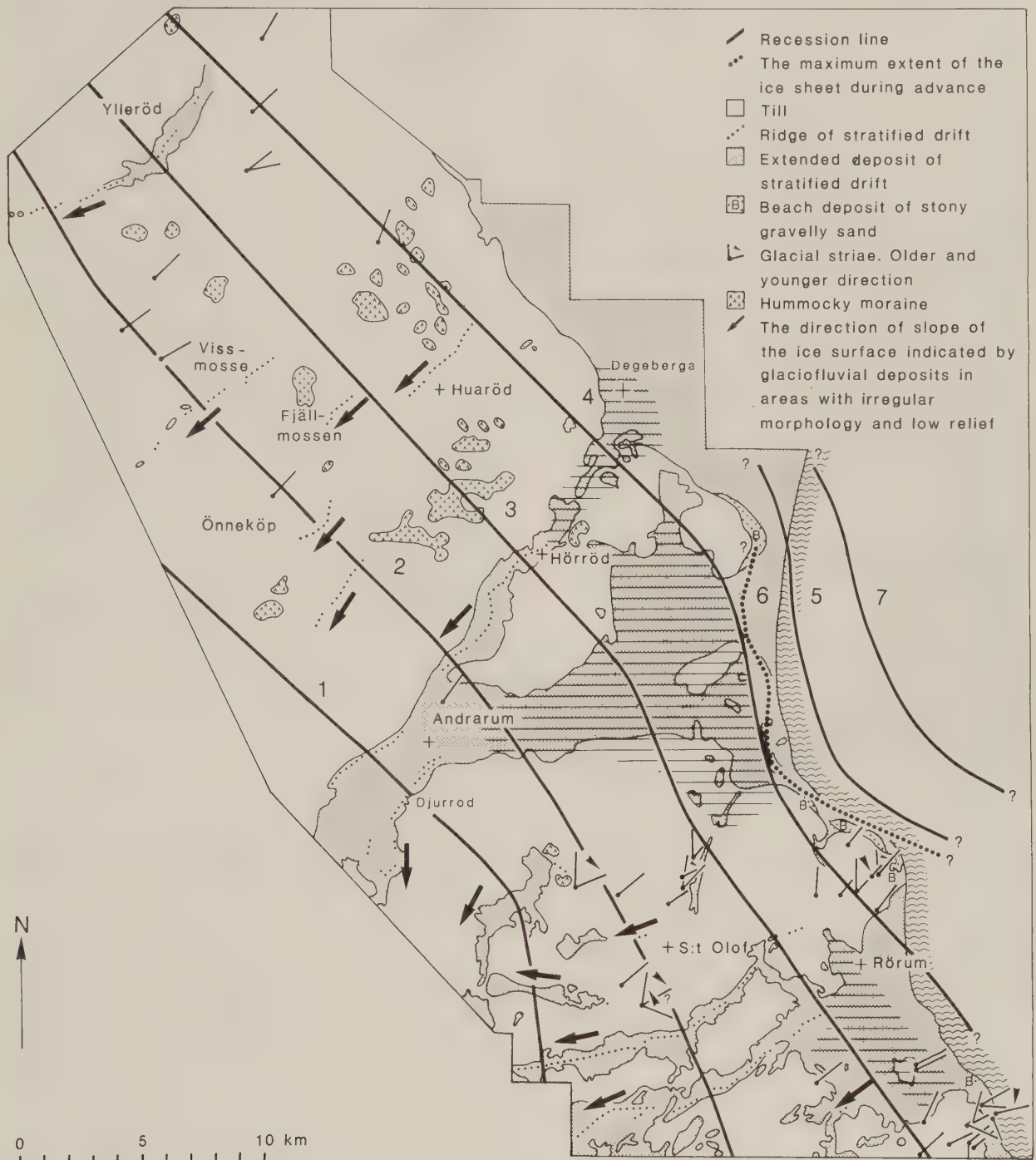


Fig. 66. The recession of the ice sheet and glacier-dammed lakes on the Linderödsåsen horst. Only glacier-dammed lakes that with certainty existed are indicated (cf. Fig. 67). Line 6 shows the maximum extent of the ice sheet when it made an advance during the recession and deposited the upper till (Plate 5). Line 5 shows the plausible westernmost position of the ice margin before the advance. However, the ice margin may have been located further toward the east in Hanöbukten Bay. The trend of line 7 is approximate.

the Baltic Ice Lake. When the ice margin was situated east of the coast-line, the Baltic Ice lake covered the low-lying areas along the eastern slope of the horst (Fig. 65F). It reached up to about 40 m a.s.l. northeast of Brösarp and up to about 20-25 m a.s.l. south-east of Rörum.

5.12 The deglaciation of the Linderödsåsen horst

5.12.1 The recession of the ice sheet

The ice sheet receded toward the northeast on the northwestern part of the Linderödsåsen horst and toward the east-northeast on the southeastern part (Fig. 66). The recession lines indicate the boundary between active and stagnant glacier ice where the deglaciation was subaerial and the ice margin where the ice sheet terminated in a lake. The recession lines are based on the trend of the zones with glaciofluvial deposits located in areas with irregular morphology and low relief, on glacial striae and on the damming of glacial lakes. The zones with glaciofluvial deposits indicate the direction of slope of the ice surface during the recession of the ice sheet (Chapters 5.1-5.9) and the recession lines are perpendicular to this direction. The glacial striae on exposed bedrock surfaces indicate the ice movement direction close to the boundary between stagnant and active glacier ice or close to the ice margin, since the ice sheet was active during the deglaciation. The activity is deduced from the gradual recession of the ice sheet and the up-slope transport of meltwater. The local damming of glacial lakes indicates the trend of the ice margin along the eastern border of the horst.

5.12.2 Standstills and advances during the recession of the ice sheet

The ice sheet did not make any significant standstills or advances on the Linderödsåsen horst with the exception of the advance along the eastern border of the horst which resulted in the upper till (Chapter 5.11.1, Fig. 66: line 6). Significant standstills or advances on the horst ought to have resulted in local enlargements of the glaciofluvial deposits during the recession of the ice sheet. However, such enlargements do not occur on the horst. It may be argued that most of the glaciofluvial sediments were transported away from the marginal zone of the ice sheet, thereby removing the evidence of a standstill or an advance. However, this is excluded on the northeastern half of the horst, since the ground surface slopes toward the northeast here. On the southwestern half of the horst, the ground surface often slopes toward the northeast along parts of the zones with glaciofluvial deposits.

The largest glaciofluvial deposits occur on the southeastern part of the horst. This does not indicate that the recession of the ice sheet was slower here than on the rest of the horst. One may deduce this since there is a close relation between the size of the glaciofluvial deposits and the size of the valleys and depressions in which deposits are found or through which the glaciofluvial sediments were transported by the meltwater. This is true for all of the horst but is especially evident on the southeastern part. Here, small

valleys and depressions with small deposits alternate with large valleys and depressions in which large deposits are found.

The distribution of hummocky moraine on the horst (Fig. 66) indicates as well that the ice sheet did not make a significant standstill or advance. Observations of existing glaciers have shown that a standstill or advance is indicated by a zone with more hummocky moraine than is found where the ice sheet retreated continuously (Okko 1955; Kozarski & Szupryczynski 1973). The observed zones trend parallel to the ice margin. However, the hummocky moraine on the Linderödsåsen horst is not concentrated to zones trending northwest-southeast, i.e., parallel to the boundary between stagnant and active glacier ice. Instead, the distribution of the hummocky moraine indicates a fairly uniform recession of the ice sheet.

5.12.3 Stagnant glacier ice in front of the active part of the ice sheet

The extended, hummocky deposits of stratified drift and the hummocky moraine indicate that a zone of stagnant glacier ice existed in front of the active part of the ice sheet during the deglaciation (Chapters 5.1-5.9). Except for in two areas, it is impossible to judge the width of the zone with stagnant ice.

In the valley in area 6 (Chapter 5.6, Fig. 18) glacier ice existed at least 5 km in front of the active part of the ice sheet when the boundary between active and stagnant ice was located 1 km north of Agusa. This can be deduced since erosion channels are not found in the stratified drift as far as 4 km south of Agusa and the ice sheet was drained through the valley at least up to the point where the boundary between stagnant and active ice was situated 1 km north of Agusa.

In area 9, stagnant glacier ice dammed the glacial lake south of Rörum (Chapter 5.9, Fig. 55). Glacier ice must have remained along the southern and western border of the depression occupied by the lake at least as long as the ice margin was situated 3 km away from the border of the depression (cf. Plate 5, recession line H).

5.12.4 The drainage of meltwater and glacier dammed lakes

Where the surface of the horst slopes toward the northeast, the drainage of meltwater ought to have been parallel to the boundary between stagnant and active glacier ice (Fig. 67). It is likely that the drainage took place in the zone with stagnant ice that was found in front of the active part of the ice sheet.

The stratified drift between Hörröd and Degeberga and in the area southeast of Hörröd indicates that glacier-dammed lakes existed here (Fig. 66). The morphology of the horst permits also the existence of other glacier-dammed lakes (Fig. 67). However, the ponding of meltwater may have been prevented by stagnant glacier ice. The absence of stratified drift in areas where ponding of water is possible is not an argument against the existence of glacier-dammed lakes here, since coarse-grained glaciofluvial sediments are only deposited in the vicinity of a meltwater conduit. The lakes in question cannot have been more than 10 m deep except along and close to the northeastern slope of the horst, i.e., along the northeasternmost recession line in Fig. 67.

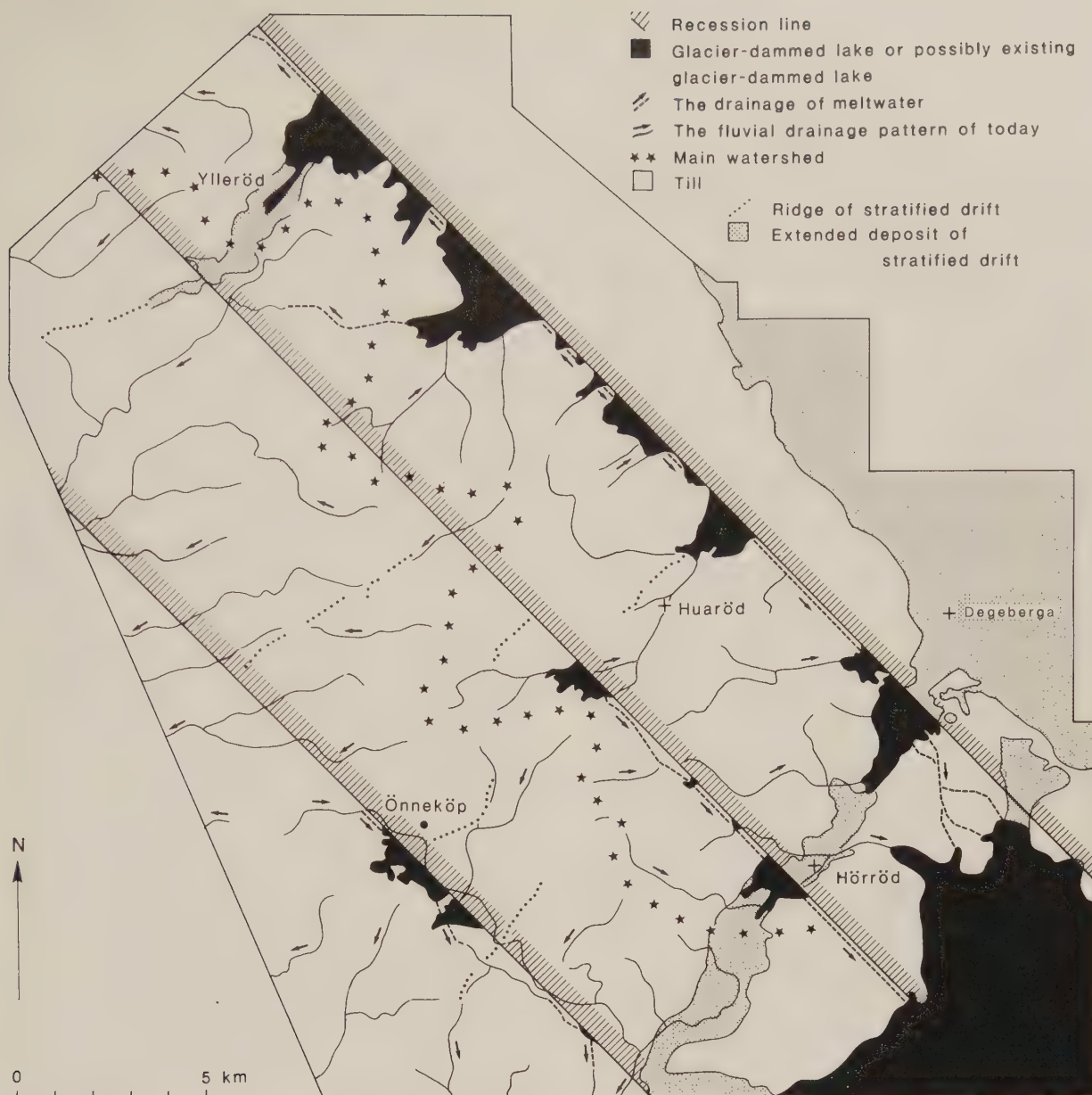


Fig. 67. The drainage of meltwater, possible glacier-dammed lakes and certain glacier-dammed lakes on the northwestern part of the Linderödsåsen horst. The certain glacier-dammed lakes are indicated in Fig. 66.

5.12.5 The highest shoreline

The highest shoreline on the eastern slope of the Linderödsåsen horst is located between

20 m and 40 m a.s.l. (Chapter 5.11.1). On the northeastern slope of the horst, the highest shoreline ought to be situated at around 50 m a.s.l.

6 The Nävlingeåsen horst and the Håglinge area

The Nävlingeåsen horst has a steep slope facing northeast that is about 75 m high in the northwestern part and 25 m high in the southeastern part (Plate 1). The top surface of the horst is dome-shaped and reaches 150 m a.s.l. in the area west of Nävlinge. The crest line of the horst trends northwest-southeast and crosses a point located 3 km south of Nävlinge. Mainly north-northeast - south-southwest trending valleys and depressions occur in the western part of the horst. The most prominent valley is 50 m deep at the mouth and located north-northeast of Nävlinge. Apart from these valleys and depressions, the surface of the horst is irregular and gently undulating, and the relative relief is less than 15 m. The ground surface in the Håglinge area slopes gently toward the northeast. Northeast-southwest trending valleys and depressions occur here, and the relative relief is less than 40 m.

The bedrock consists mainly of gneiss and gneissic granite (Kornfält et al. 1978). Outcrops of syenite occur above all along the northeastern border of the horst. The boundary between these types of rocks and the Cretaceous limy sandstone, sandy limestone and limestone northeast of the horst (Fig. 57) follows the 50 m contour line. Cretaceous rocks also occur south of an east-northeast - west-southwest trending line crossing Vå. Except in the areas north of Nävlinge and east of Håglinge, bedrock exposures seldom occur.

The glacial striae indicate an ice movement from between the north-northeast and the northeast. Striae indicating an ice movement from the north-northwest occur at a site located 8 km southeast of Nävlinge. It has not been possible to judge their age relation relative to the northeasterly and predominating striae occurring here (Karlsson 1879).

Sandy till predominates the glacial deposits. It is 5-10 m thick in areas where gneiss and gneissic granite make up the bedrock. The till resting on the Cretaceous bedrock is sometimes considerably thicker and may be underlain by sand. Hummocks of till that are 50-100 m in diameter and about 4 m high occur southwest of Nävlinge. However, the till forms mainly a cover reflecting the irregularities of the underlying bedrock surface.

In the western part of the area, roughly northeast-southwest trending zones with glaciofluvial deposits are found. They are composed of ridges, mounds and hummocks of mainly stony gravelly sand and extended deposits of sand. The glaciofluvial deposits are described at length in Chapter 6.1.

According to E. Nilsson (1942, 1953, 1968), bench marks and beach deposits occur at four sites on the slope of the Nävlingeåsen horst. They reach up to between 98.0 and 103.0 m a.s.l. in the area west-northwest of Önnestad and up to 48.0 m northwest of Vå. According to Nathorst (1882), a beach deposit of stony gravelly sand occurs 3 km south of Önnestad. It is about 500x75 m large and according to the Topographical Map is located 45-50 m a.s.l. I have found that beach deposits of stony gravelly sand are common south and west of Önnestad up to 50 m a.s.l. Beach deposits do not overlie the till at site 128 (Chapter 6.1.2), 2.5 km southwest of Önnestad. The surface of the till here reaches 70-90 m a.s.l.

6.1 Area 10. The Nävlinge - Håglinge area

6.1.1 General Description

Three mainly north-northeast - south-southwest trending valleys occur on the horst in area 10 (Fig. 68). Only a part of the valley 5 km northwest of Nävlinge is located in area 10. It is 250 m wide, 40 m deep and the valley floor slopes toward the north-northeast. The valley 3 km west-northwest of Nävlinge, which runs into the above-described valley, is 40 m deep at the mouth and has a southwestward sloping floor. The deepest valley in area 10 is situated north-northeast of Nävlinge. It is 50 m deep at the mouth and from there it becomes shallower toward the south-southwest and disappears at Nävlinge. A 250 m wide and 5-10 m wide depression is found between the deposit of sand 1.5 km south of Nävlinge and a point located 3 km northeast of Bjärröd. About 3 km northeast of Bjärröd, the depression splits into two 5-10 m deep and irregular depressions that terminate at Bjärröd and 1.5 km southwest of Nockarp respectively. The morphology in the areas surrounding the above-described valleys and depressions is irregular and the relative relief is less than 15 m.

The northwest-southeast trending and southwest-facing slope of the horst north and northeast of Ljungarum is steep. It is 75 m high north of and 30 m high northeast of Ljungarum.

Between Bjärröd and Lake Sjöbergasjön, the ground surface slopes toward the northeast, and southwest of this lake toward the southwest. The relative relief is mainly less than 40 m. Northeast-southwest trending valleys and depressions occur between the irregular heights in this area.

Hellberg (1964) distinguished zones with north-south trending ridges east of Bjärröd and northwest-southeast trending ridges southwest of Bodarp. In these areas I have observed only hummocks and short, irregular ridges of varying orientation.

The glaciofluvial deposits 2.5 km south-southeast of Sjöbergasjön Lake are located on the eastern side of a depression. The ground surface in the close vicinity of the deposits reaches about 110 m a.s.l.

The ridge of stony gravelly sand northeast of Sjöbergasjön Lake is situated between less than 15 m high mounds. The ground surface in the close vicinity of the ridge reaches 105-110 m a.s.l. at Sjöbergasjön Lake, 115-120 m a.s.l. at the central part of the ridge and 105-110 m a.s.l. at the northern end of the ridge. The ridge is 2-3 m high at Sjöbergasjön Lake and 5-8 m high 500 m northeast of this lake (Rydenheim 1973). The deposits northeast of the ridge are situated between 5-25 m high heights. The ground surface in the close vicinity of the deposits reaches about 100 m a.s.l. The surface of the peat bog northeast of the deposits is located at about 80 m a.s.l.

The glaciofluvial deposits southwest of Bosarpssjön Lake are located in a northeast-southwest trending valley that is 200-500 m wide and about 10 m deep. The valley floor slopes toward Bosarpssjön Lake. A northeast-southwest trending valley is located northeast of Bosarpssjön Lake. Immediately north of the lake, the valley is only some meters deep



Fig. 68. Geology and morphology in area 10, the Nävlinge - Häglinge area. The contour interval is 25 m.

and the valley floor reaches 115-120 m a.s.l., while it reaches about 90 m a.s.l. 1 km

northeast of Bosarpsjön Lake. From here and northeastward, the valley is up to 600 m

wide and about 30 m deep, and the valley floor slopes gently toward the northeast.

The zone with glaciofluvial deposits between GöingeHolm and Bjärröd is located between irregular and less than 25 m high heights in the prolongations of the depressions at Bjärröd and Nockarp. The ground surface in the close vicinity of the deposits reaches about 100 m a.s.l. Ridges, mounds and hummocks constitute the morphological elements of the deposits. The ridges consist of stony gravelly sand. Gravelly sand and sand make up the mounds and the hummocks (Hellberg 1947; Rydenheim 1973).

The description below of the glaciofluvial deposit at Ljungarum is based on the investigations made by Hellberg (1947, 1964). The deposit is 3 km long, 1.5 km wide and up to 15 m thick. It is dissected by rivulets and has an even top surface that slopes toward the southwest. The surface reaches 118.5 m a.s.l. in the northeast and 106 m a.s.l. in the southwest. The deposits are primarily made up of sand but stony gravelly sand also occurs. The sand forms bottomset beds and foreset beds. The latter are often overlaid by a topset bed of stony gravelly sand. The stony gravelly sand north-northeast of Ljungarum has a hummocky relief. A ridge of stony gravelly sand occurs east-southeast of Ljungarum. Clay is found below the peat in the peat bog southwest of Ljungarum (T. Nilsson 1935).

I have investigated eight sand-pits in the Ljungarum deposit, three of which are described in Chapter 6.1.2. Paleocurrent analyses in the pits indicate that the sand was deposited by meltwater currents from on an average 30°.

The ground surface surrounding the ridge north of Bodarp, trending northeast-southwest, is gently undulating and reaches 140-145 m a.s.l. The ridge is continuous, has a triangular cross-section and is 5-10 m high (Rydenheim 1973). Ridges are missing on the steeply dipping slope southwest of Bodarp. According to Hellberg (1947) two shallow and northeast-southwest trending depressions occur here.

The deposit of sand south of Nävlinge is located in a less than 5 m deep depression and has a gently sloping surface.

The deposits of stony gravelly sand and sand in the valley north-northeast of Nävlinge are dissected by brooks and reach 120-140 m a.s.l. north of Nävlinge and about 50 m a.s.l. at the mouth of the valley.

6.1.2 Exposures

For practical reasons site 128, which is located outside area 10, is described in this section.

Sites 123-126

The location of sites 123-126 is shown in Fig. 68.

Site 123 - A 75x75 m large and 10 m deep sand-pit, located in a mound and described by Rydenheim (1973). Sand and gravel predominate in the pit.

Site 124 - A 300x75 m large and up to 8 m deep sand-pit. The sand forms a delta foreset bed which is up to 8 m thick. The foresets dip about 25°, consist of sand with flat lamination, and indicate a paleocurrent from on an average 40°.

Site 125 - A 160x120 m large and 10 m deep sand-pit, displaying a delta topset, foreset and bottomset bed (Fig. 69). The topset bed is 0.5-1.5 m thick and consists of stony gravelly sand in which horizontal and up to 1-3 m long and 5-10 cm thick beds of gravelly sand and sand occur. Beds of gravelly sand alternating with beds of medium and fine sand constitute the 3-7 m thick foreset bed. The foresets are curved, dip 15-25° in their upper parts and indicate a paleocurrent from 5°. The beds of gravelly sand taper downward and flat lamination makes up the internal stratification. The beds of medium and fine sand are often thicker in the lower part than in the upper part of the foreset bed. They often pass gradually into the bottomsets and are ripple-laminated (xy plane: type A, yz plane: troughs). The visible part of the bottomset bed is 2-4 m thick and consists of horizontal or gently inclined beds of medium and fine sand with some silt. Ripple lamination (xy plane: type A, yz plane: troughs and xy plane: type B, yz plane: troughs and parallel lamination) indicates a paleocurrent from on an average 10°.

Site 126 - A 100x40 m large and 7 m deep sand-pit, displaying a delta foreset and bottomset bed. The foreset bed is about 4 m thick. Coarse and medium sand with flat lamination make up the foresets which dip about 20° in their upper parts. The visible part of the bottomset bed is about 3 m thick and is mainly made up of medium and fine sand with ripple lamination (xy plane: type A, yz plane: troughs). The ripple lamination and the foresets indicate a paleocurrent from 50° on an average.

Site 127

Description - Site 127 is a 500x200 m large limestone quarry located 2 km southeast of Ignaberga (Fig. 68). The limestone is overlaid

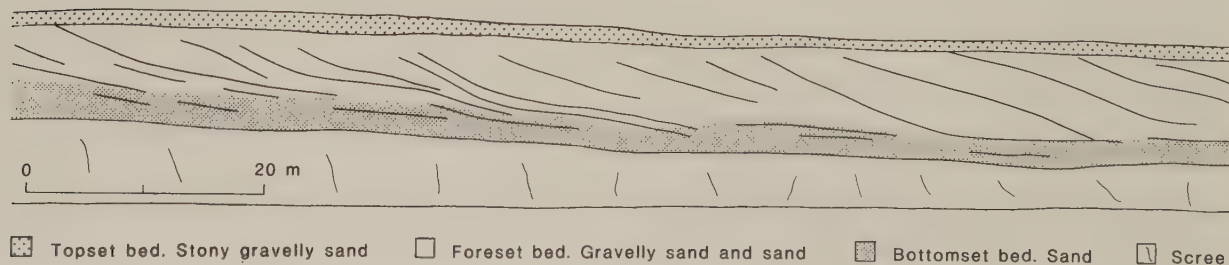


Fig. 69. Delta topset, foreset and bottomset beds at site 125. The section is orientated at 0-180° and faces the west.

by an up to 15 m thick bed of glacial deposits, consisting of two till beds interbedded by stratified drift. The deposits in the north-western part of the pit have been described by Åmark (1979).

The lower till is 1-10 m thick and rests directly on the bedrock. It is silty and the boulder and stone content is low. The lower part of the till is rich in limestone fragments, whereas crystalline rocks predominate in the upper part. The till fills fractures in the limestone (Fig. 70). High and low-angle fractures were observed in separate parts of the till. Where high-angle fractures occur, the long axes of stones are parallel to the strike of the fractures, which on an average is at $115-295^\circ$. Elongated slabs of limestone occur along the low-angle fractures (shear planes). The long axes of stones are perpendicular to the strike of the shear planes. The shear planes dip about $0-25^\circ$ toward the north-northeast and strike at $110-290^\circ$.

The stratified drift overlying the lower till forms as much as 120 m long and up to 5 m thick and continuous beds of stony gravel, stony gravelly sand and sand. The boulders and stones are mainly of crystalline rocks, whereas limestone fragments are common in the sand-size fraction. Planar cross-lamination in the sand indicates a paleocurrent from the north.

The upper till is 3-12 m thick and rests on the lower till or on the stratified drift that overlies the lower till. It is sandy and the boulder and stone content varies between low and moderate. Cretaceous rock fragments are common in the sand-size fraction and igneous rocks predominate in the coarser fractions. Horizontal and up to 4 m long and some centimeters thick beds of sand with flat lamination occur. In between these beds, deformed strata and bodies of mainly sand are common. Floes of limestone occur along the base of and in the lower part of the upper till. The largest floe is 20 m long and 0.6-1.0 m thick. It rests on the lower till which is folded beneath the floe. At the points of contact with the upper till, parts of the floe



Fig. 70. Injections of the lower till in horizontal and vertical fractures in the Cretaceous bedrock at site 127. A flow of limestone occurs at the boundary between the upper and lower till. The section is orientated at $65-245^\circ$ and faces the southeast.

are mixed with till and stratified drift. The floe is folded and slabs of it are torn away (Fig. 71). Fabric analyses in the upper till show that the long axes of stones are orientated at $30-210^\circ$ on an average.

Discussion - The lower till was deposited at the base of an active ice sheet with a direction of movement from the north-northeast (from about 20°), which is indicated by the fabric analyses, the fracture systems and the lithological composition of the till.

The lithological composition and the fabric analyses in the upper till show that it was deposited by an ice sheet with a direction of movement from the north-northeast (from about 30°). The ice sheet was active at least when the lower part of the till was deposited, since the upper part of one flow occurring at the base of the till is deformed and, con-



Fig. 71. A folded part of a limestone floe at the base of the upper till at site 127. The floe is injected with till and stratified drift. The section is orientated at $160-340^\circ$ and faces the east. The folding rule is divided into 10 cm long sections.

sequently, the floe was dragged along the surface of the lower till. The occurrence of alternating deformed and undeformed strata of drift in the upper till may indicate that the ice sheet was active when all of the till was deposited.

The northerly sloping till and bedrock surface indicates that the stratified drift between the lower and the upper till accumulated in contact with the ice sheet. The length and the thickness of the beds of stratified drift suggest that the deposition took place in a marginal zone of the ice sheet.

Site 128

Description - Site 128 is a quarry located in the slope of the Nävlingeåsen horst, 2.5 km southwest of Önnestad (Plate 1). Some of the results from the investigations of the exposures in till occurring here will soon be published (Åmark in press).

The till rests on a 1x2 km large outcrop of syenite. The bedrock surface is irregular and slopes toward the northeast. Glacial striae below the till indicate an ice movement from about 20°. The till consists of two beds. Syenite fragments predominate in the lower till bed. It is situated mainly between bedrock knobs and the boundary to the upper till coincides roughly with the top surfaces of the bedrock knobs. Well-defined and distinctly-laminated beds of sand, trending parallel to the slope of the bedrock surface, alternate with irregular and diffusely laminated bodies of sand and poorly-sorted material with diffuse strata and bodies of sand (Fig. 72). Shear planes indicate a deforming force roughly toward the south. The upper till is dominated by fragments of gneiss and granite. Similar to the lower till, it is rich in stratified drift displaying a varying degree of deformation. Fold axes in the upper till strike on an average at 120-300°.

Discussion - The tills were deposited at the base of an active ice sheet with a direction of movement from the north-northeast. The lower till was formed by erosion of the local syenite bedrock and deposition of fragments from it after a short distance of transport. Subglacial meltwater deposited beds of sand at the base of the ice sheet. The beds became more or less disturbed by the active ice. When the syenite bedrock was covered by till, melt-out of englacially-transported drift predominated. Melt-out of drift along with deposition and deformation of stratified drift at the base of the ice sheet resulted in the upper till.

6.1.3 Discussion

Hellberg (1947, 1964) showed that the deposit of sand at Ljungarum is a delta. The shallow valleys southwest of Bodarp and the ridge north of Bodarp were considered to indicate the routes along which the sand making up the delta was transported by the glacial meltwater. This conclusion is supported by my paleocurrent analyses in the delta, indicating meltwater streams from the north-northeast.

According to Hellberg, the sand constituting the delta accumulated in a glacial lake that reached 116 m a.s.l. at Ljungarum. She thought that the lake was dammed by the ice sheet in the low-lying area east of Bjärröd. A roughly north-northwest - south-southeast trending ice margin was indicated

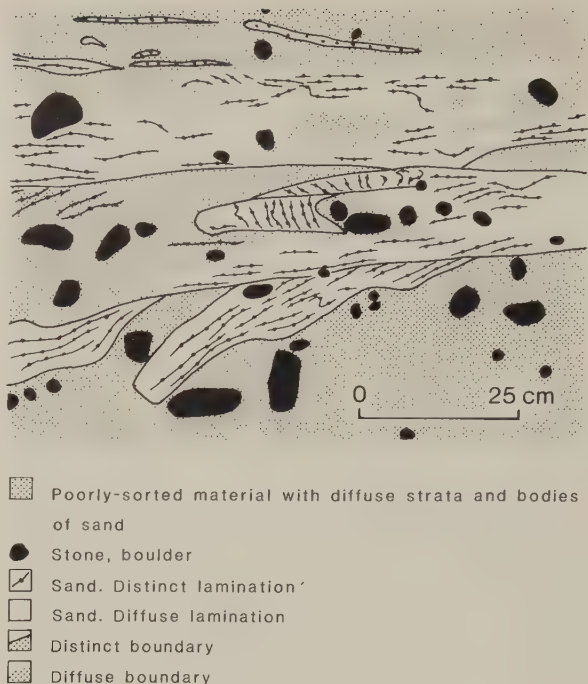


Fig. 72. Site 128. Beds of sand with distinct lamination resting in a poorly-sorted material with diffuse strata and bodies of sand. The figure shows a part of a section that is orientated at 160-340° and faces the west.

here by ridges which were interpreted to be terminal moraines. I do not think that the ridges of varying orientation in the area east of Bjärröd are terminal moraines. However it seems likely that stagnant or active glacier ice dammed the lake in the area around Bjärröd, since there are no signs of high-water levels on the northeastern slope of the Linderödsåsen horst apart from the sand at Degeberga, which was deposited in a local glacier-dammed lake.

The sand in the valley north-northeast of Nävlinge indicates that a glacier-dammed lake occurred here and that the deposition of the stratified drift took place at the margin of the ice sheet.

The relative relief in area 10 is less than 50 m and in large parts of the area less than 20 m. The glaciofluvial deposits are located in valleys, depressions and between heights. The valleys, depressions and the low-lying areas between the heights often have northeastward-sloping floors. This relation between the morphology of the landscape and the glaciofluvial deposits is possible to explain if the glaciofluvial sediments were transported by meltwater flowing along the base of the ice sheet, the ice sheet had a sloping surface and the accumulation of the sediments took place directly on till or bedrock. The relief in area 10 is so low that the heights occurring here cannot have protruded above the ice surface, thereby controlling a supra-glacial drainage. The large number of supra-glacial meltwater streams that ought to have existed on the ice surface cannot have been concentrated to the valleys and the depressions by drainage in stagnant and disintegrating glacier ice, since the floors of the valleys and depressions often slope toward the northeast.

The stratified drift south and southwest

of Ljungarum accumulated before the sand making up the delta at Ljungarum. The delta and the ridge north of Bodarp were formed before the sand in the valley north-northeast of Nävlinge was deposited. This shows that the ice sheet receded by gradual stages toward the northeast.

The part of the ice sheet in which the transport of the glaciofluvial sediments took place was active, since it had a sloping surface and receded by gradual stages. The morphology of the ridges of stratified drift show no signs of disturbance by active ice, which indicates that they were formed in stagnant glacier ice. Thus, in those parts of area 10 where calving did not take place, stagnant ice occurred in front of the active part of the ice sheet, which also is indicated by the hummocky moraine in area 10.

The surface of the ice sheet sloped toward the southwest during the accumulation of the stratified drift making up the ridges northeast of Sjöbergasjön Lake and north of Bodarp, since the relief here is low and cannot have controlled the main flow direction of the subglacial meltwater.

When the ice sheet receded in area 10, at least at the base it was mainly at the pressure melting point, as meltwater by then flowed along the base.

6.2 The deglaciation of the Nävlingeåsen horst and the Häglinge area

Glaciofluvial deposits are found in the Häglinge area and on the western part of the Nävlingeåsen horst. Valleys occur in these areas, but not on the eastern part of the horst. The absence of glaciofluvial deposits in the latter area shows that the valleys and depressions concentrated the subglacial meltwater of the ice sheet, which resulted in glaciofluvial deposits.

The glaciofluvial deposits in area 10 indicate that a zone of stagnant ice existed in front of the active part of the ice sheet and that the ice sheet in a northeasterly direction became stagnant by gradual stages. On the basis of this, one can assume that most of the glacial striae occurring on exposed bedrock surfaces indicate the ice movement direction which prevailed immediately before the ice became stagnant. Consequently, both glacial striae and glaciofluvial deposits located in areas with low and irregular relief show that the ice sheet on the Nävlingeåsen horst and in the Häglinge area receded toward a direction between the north-northeast and the northeast (Fig. 100).

The highest shoreline on the northeastern slope of the Nävlingeåsen horst is uncertain. However, it seems likely that E. Nilsson's (1942, 1953, 1968) observations are not correct and that the highest shoreline is located at about 50 m a.s.l.

7.1 Morphology, bedrock and glacial striae

The central and eastern parts of the plain around Kristianstad (Plate 1) are mainly located below 10 m a.s.l., whereas the surrounding parts reach up to about 30 m a.s.l. The plain has an even or gently undulating surface above which hills up to 100 m high rise in the north.

In the northern part of the plain, gneiss, gneissic granite and granite are found (Fig. 57). Knobs of these types of bedrock form parts of the drumlin-shaped hills occurring around Ivösjön Lake and on the peninsula of Listerlandet. Sedimentary kaolin and kaolinization of the crystalline bedrock have been observed (Bergsten 1972; Bergström & Sundquist in Kornfält et al. 1978; Bergström & Shaikh 1980). Cretaceous rocks consisting of limy sandstone, sandy limestone and limestone dominate the bedrock (Kornfält et al. 1978; Bergström & Shaikh 1980). Clayey sediments from the Tertiary occur in the area around Åhus (Bergström & Shaikh 1980). Irregular and north-south to northeast-southwest trending depressions occur in the Cretaceous bedrock (K. Nilsson 1968; Gustavsson et al. 1979). Bedrock exposures occur seldom and the Cretaceous bedrock is mainly known from bores.

The majority of the glacial striae indicate an ice movement from between the north and the northeast (Lindström 1877; Nathorst 1882; G. De Geer 1889b; Blomberg 1900; Johnsson 1951, 1956; Hellberg 1971). At three sites, located 11 km northwest of Kristianstad, 7 km northwest of Färlöv and 5 km northeast of Färlöv, striae suggesting an older ice movement from between the north-northwest and the north occur (G. De Geer 1889b). According to G. Johnsson (1951, 1956) and Hellberg (1971), the predominating glacial striae and crescentic fractures indicate an ice movement from between the north-northwest and the north-northeast east of Ivösjön Lake and on Listerlandet. They have also observed striae and crescentic fractures which were considered to indicate older ice movements from roughly the northwest and the northeast.

7.2 Till

7.2.1 General description

The till is usually about 10 m thick and the greatest observed thickness is about 40 m (K. Nilsson 1968). Thin covers of till occur in the area 14–19 km northeast of Åhus. Well bore logs, excavations and information from farmers show that the till here often makes up a less than 1 m thick cover on the heights, whereas it is thicker in the depressions between the heights. Till is often absent below the glaciofluvial deposits (K. Nilsson 1968; Gustavsson et al. 1979).

The till on the plain resting on Cretaceous bedrock has an even or gently undulating surface. The latter is also the case outside the coast-line, which is reflected by the islands northeast of Åhus. The depth curves on the Topographical Map and on the nautical chart 'Ölands södra udde - Sandhammaren, Ufs nr. 1980:46, Edition 80-11' show that an

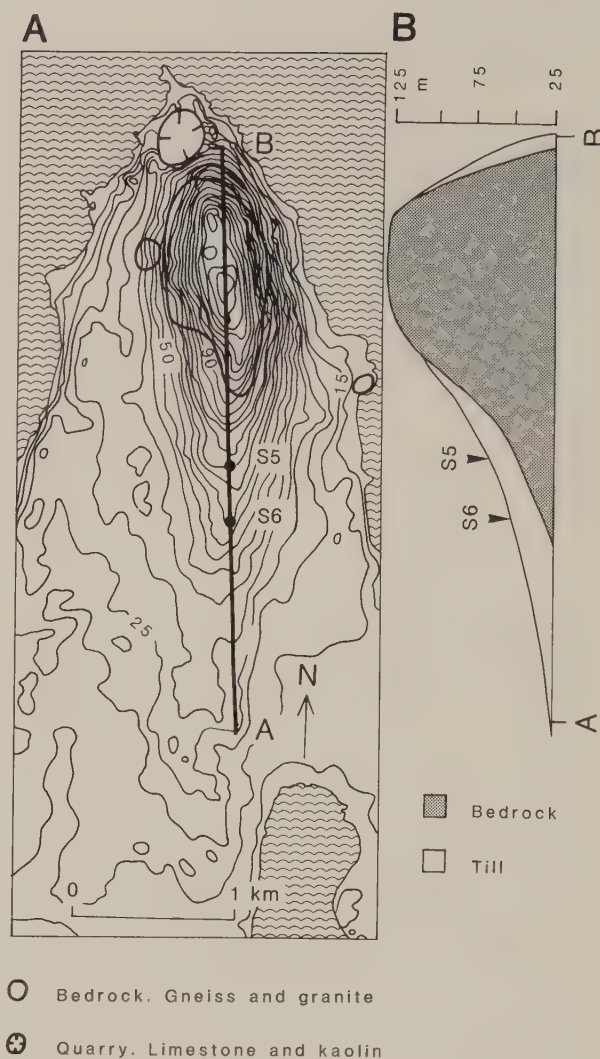


Fig. 73. The drumlin-shaped hill on the island of Ivön (Plate 1). A. Morphology. The contour interval is 5 m. Exposures of gneiss and granite as well as the limestone and kaolin quarry on the northernmost part of the island are indicated. B. North-south trending profile through the hill based on bedrock exposures and seismic investigations. The location of the profile is shown in Fig. 73A.

undulating morphology occurs in an up to 15 km wide zone along the coast-line from Listerlandet to immediately south of a northwest-southeast trending line crossing Åhus and the shoals of Kiviksbredan 12 km southeast of Åhus.

Drumlin-shaped hills occur in the area around Ivösjön Lake and on Listerlandet. The most prominent hill in the area around Ivösjön Lake is located on the island of Ivön (Fig. 73). It trends north-south, is about 5 km long, 0.5–1 km wide and up to 110 m high. Bedrock exposures and seismic investigations (Chapter 7.2.4) show that the hill consists mainly of a knob of granite, on the



○ Bedrock. Gneiss and granite

Fig. 74. The drumlin-shaped hills on the peninsula of Listerlandet and the ridges southeast of Listerlandet in Hanöbukten Bay. A. Morphology. The contour interval is 5 m. Exposures of gneiss and granite are indicated. B. Profile through one of the hills based on bedrock exposures and seismic investigations. The location of the profile is shown in Fig. 74A. C. The ridges southeast of Listerlandet.

southern side of which a tail of till occurs. The drumlin-shaped hills on Listerlandet trend north-south to north-south-east - south-south-west (Fig. 74A and B). The hills are 4-9 km long. This is a minimum length, since the depth curves of the Topographical Map reach only 6 m below the level of the sea. The hills are 0.3-1.5 km wide and up to 75 m

high. Bedrock exposures, the irregular morphology of the hills and seismic investigations (Chapter 7.2.4) show that mainly bedrock with a cover of till form the hills. The depth curves on the nautical chart 'Ölands södra udde - Sandhammaren' show that north-north-east - south-southwest trending ridges occur southeast of Listerlandet (Fig. 74C). The

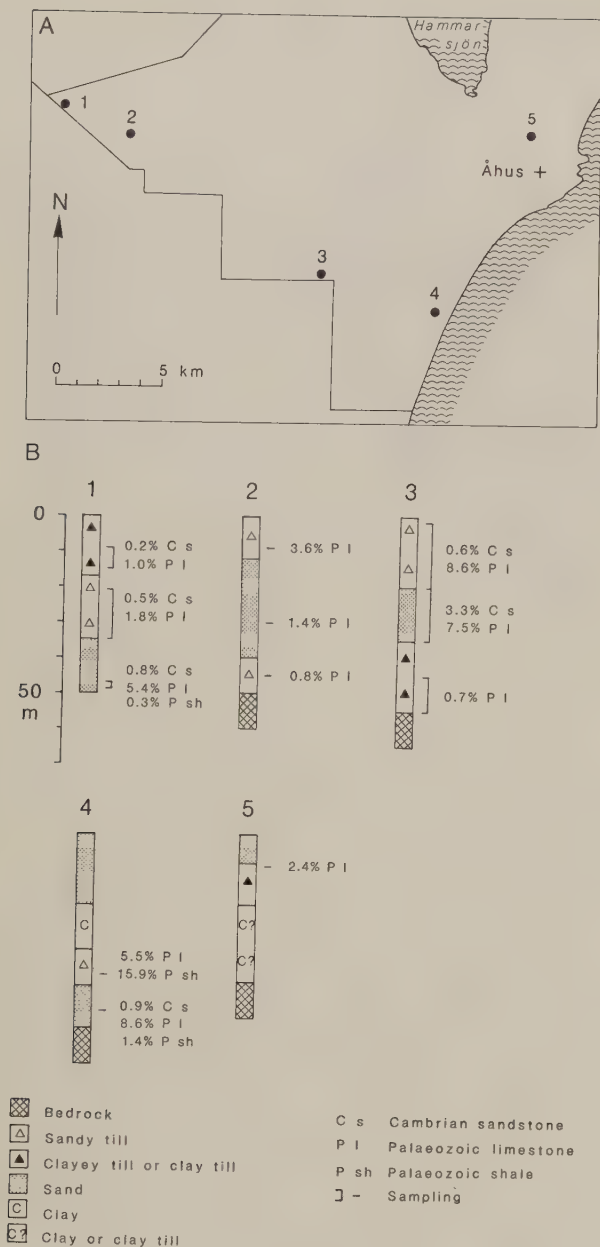


Fig. 75. The occurrence of Palaeozoic rock fragments in till and stratified drift south of Hammar-sjön Lake according to K. Nilsson (1968). The sampling took place in connection with well borings. A. Location of well bores. B. Well bore logs and lithological composition of the drift.

ridges are about the same size as the drum-lin-shaped ridges on the peninsula.

Well bore logs indicate that the till rests mainly directly on the bedrock (K. Nilsson 1968). In places, however, it is underlain by stratified drift, and double till beds interbedded by stratified drift have been observed.

Exposures and well bore logs show that the till mainly is sandy. However, some well bore logs indicate that clayey till or clay till also occurs. The boulder and stone content of the till is moderate to low.

The lithological composition of the till has been investigated by K. Nilsson (1968) in the area south of Hammar-sjön Lake. He found by

sampling in connection with well borings that the till in the size fraction 2-4 mm was predominated by fragments of Cretaceous and crystalline rocks but also contained Cambrian sandstone, Palaeozoic limestone and Palaeozoic shale (Fig. 75). Well bore log 1 in Fig. 75 corresponds to Nilsson's log Tollarp 6, 2 to Tollarp 9, 3 to Vittskövle 17, 4 to Vittskövle 8 and 5 to Åhus 11b.

Boulders of mica quartzite from the outcrop of mica quartzite between Immeln Lake and Näsrum in the valley landscape north of Kristianstad (Chapter 8.1, Fig. 57) occur in the till around Ivösjön Lake and Oppmanna-sjön Lake (G. De Geer 1889b).

The origin of the till has been studied in two exposures which are presented in Chapter 7.2.2. The dispersal of boulders from a hill of granite protruding above the Cretaceous bedrock surface has been investigated and is described in Chapter 7.2.3.

7.2.2 Exposures

Site 129

Description - The site is a 300x150 m large and up to 10 m deep gravel-pit located 2.5 km south of Kiaby (Plate 6). The stratified drift in the gravel-pit consists of horizontally-bedded stony gravelly sand and sand. Trough cross-stratification is common and indicates paleocurrents from between the north and the northeast. A mound of till occurs in the central part of the pit. The visible part of the mound is about 100 m in diameter and the difference in height between the top of the mound and where the sides disappear beneath the overlying stratified drift is 5-10 m. Before removal, the top surface of the mound was covered by an about 1 m thick bed of stony gravelly sand. Some cuts, mainly located in the north side of the mound, exhibit a sandy till with low stone and boulder content. The till consists largely of deformed stratified drift and the genesis has been discussed by Åmark (1978). A previously unpublished section is described and discussed below.

The section (Fig. 76A) is located in the central part of the mound. The surface of the mound here is horizontal but slopes in a northward direction immediately north of the section. The section is orientated at 30-210° and faces the northwest. It is 15 m long and 5 m high. Three units, named A-C, were distinguished.

Unit A is composed of a sandy material, the sorting of which varies between normal and poor. The boulder and stone content is low and the occurring boulders and stones are rounded to subangular. Irregular strata of sand, some with flat lamination, and bodies of sand (Fig. 76B), without lamination or with diffuse lamination, are rather common. An about 30 cm wide and at least 1.5 m deep clastic dike (cf. site 130) occurs in section 1-2. It consists of laminated sand. The laminae trend parallel to the boundaries of the dike. Irregular bodies of sand occur immediately northeast of the dike. A 1x1 m horizontal cut showed that the dike trends east-west and that the sand here is also laminated parallel to the boundaries of the dike.

Unit B consists mainly of beds and bodies of alternating fine sand, medium sand and coarse sand. The coarse and medium sand contains rounded to subangular stones and gravel-sized particles. The beds and bodies of sand are more or less deformed. Gradual transitions occur between slightly deformed,

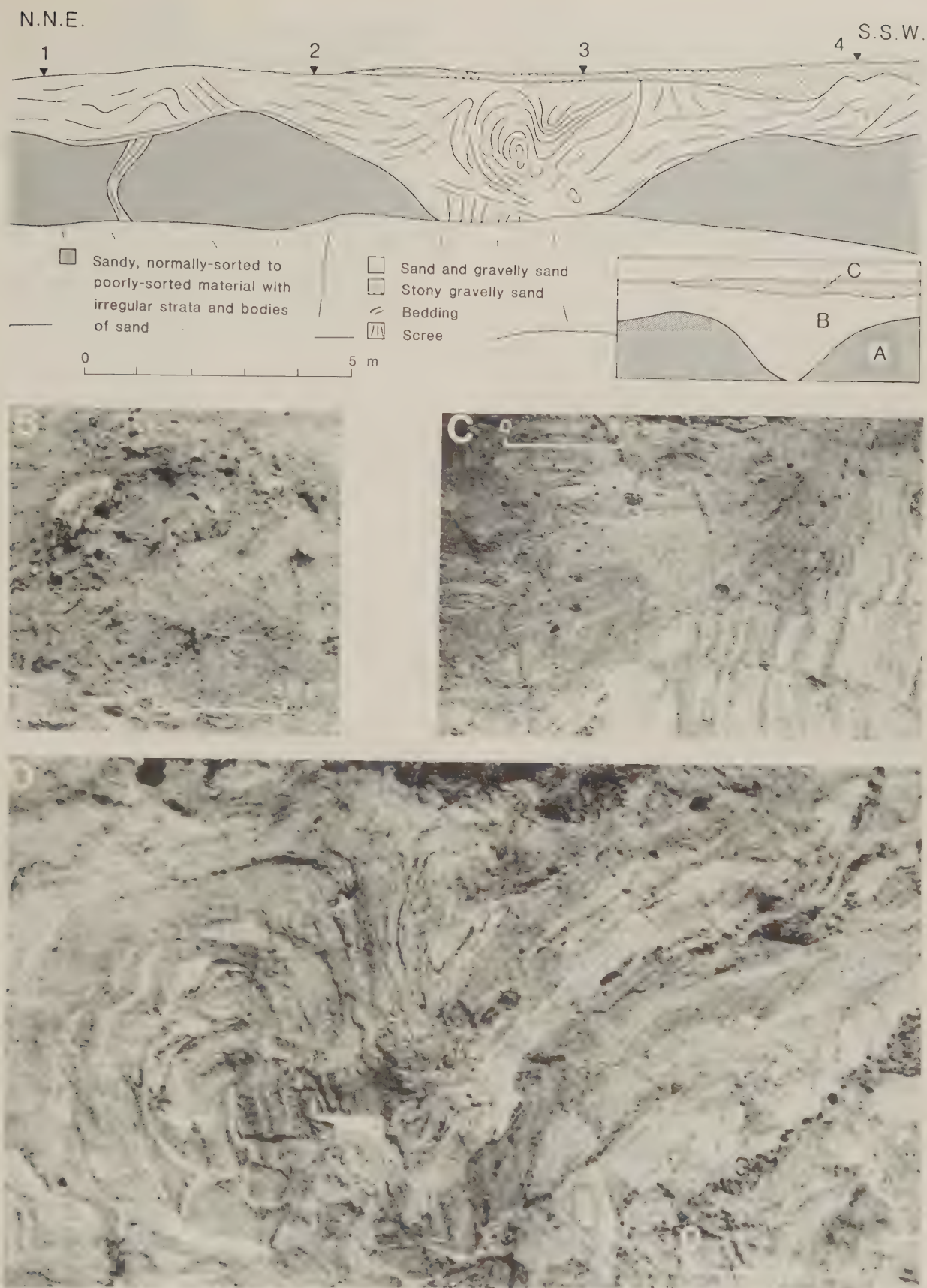


Fig. 76. Section 1-4 at site 129. The section is orientated at $30-210^\circ$ and faces the northeast. A. Survey of the section. The inset shows the three distinguished units, named A, B, and C. B. Interbedded bodies of sand in unit A, section 3-4. C. Gradual transition between diffusely and distinctly laminated drift in unit B. Low-angle faults indicate a displacement toward the south-southwest. The figure is a close-up of the upper part of the north-northeasternmost fold in section 2-3. D. Close-up of the folds in the south-southwestern part of section 2-3.

distinctly laminated beds with well-defined boundaries and strongly deformed beds, without lamination or with diffuse lamination and diffuse boundaries (Fig. 76C). In the latter case, the drift in unit B resembles the drift in unit A.

The beds of sand in section 1-2, the north-northeastern part of section 2-3 and the central and south-southwestern parts of section 3-4, trend mainly parallel to the boundaries of unit B and are irregularly folded. Low-angle faults in the steeply dipping beds in section 1-2 display a deforming force directed roughly toward the south. Folds occur in the central part of section 1-4 (Fig. 76D). A 2x2 m horizontal cut 1 m below the top-surface of unit B, showed that the folded beds trended east-west in the horizontal plane. In the folds, 5-10 cm displacements toward the south have taken place along low-angle faults (Fig. 76C).

Unit C is 0.3-1.1 m thick and consists of stony gravelly sand. It is a part of the stratified drift that overlies the mound of till in which section 1-4 are located.

Discussion - The clastic dike in unit A, the fold axes and the low-angle faults in unit B indicate that the deforming force was from 0° or from the north. This direction of deformation is supported by the shape of the folds in the central part of section 1-4, indicating that the stratified drift in the north-northeastern part of unit B slid onto unit A and was pressed against the drift in the south-southwestern part of the unit (Fig. 77). An active ice sheet must have been the cause of the deformation, since section 1-4 is located in the top of the mound and the surface of the mound slopes toward the north immediately north of the section, which excludes deformation due to mass movement. It is likely that a large part of the drift in unit A is strongly deformed stratified drift, as deformed strata and bodies of sand occur here and the drift in unit A resembles the strongly-deformed parts of unit B.

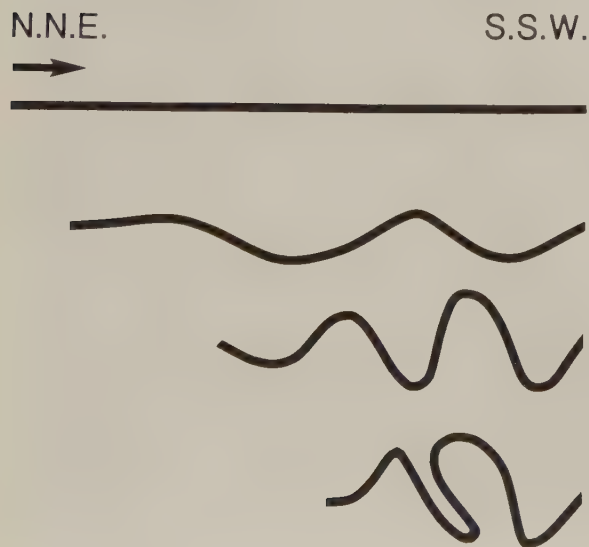


Fig. 77. Principal sketch of the formation of the folds in the central part of section 1-4 in Fig. 76A. The deforming force was directed toward the south-southwest.

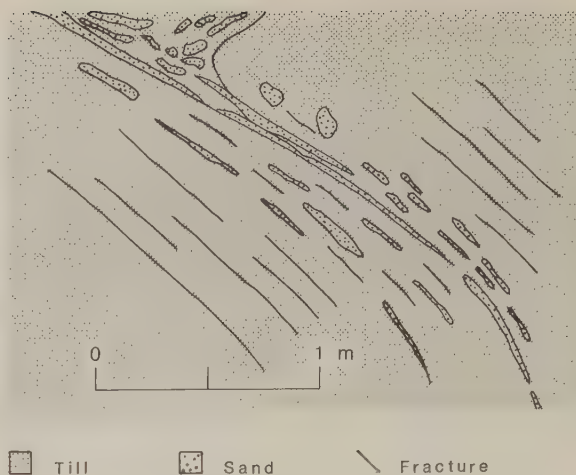


Fig. 78. Clastic dike in till at site 130. The figure shows a part of a section orientated at 140-320° and facing the west.

Site 130

Description - The site is a 500x150 m large and up to 15 m deep gravel-pit located 2.5 km west of Kiaby in the southern part of the glaciofluvial deposit of gravelly sand west of Oppmannasjön Lake (Plate 6). A 1-4 m thick bed of till with a horizontal top surface is exposed in the central part of the pit. The till is overlaid by horizontally-bedded stony gravelly sand. Horizontally-bedded sand predominates in the rest of the pit. An at least 4 m thick bed of stratified drift underlies the till.

The till is grey, silty and massive. It is very hard and the boulder and stone content is low. The boulders and stones are angular to subrounded. The boundary between the till and the underlying stratified drift is diffuse and more or less deformed beds of till and stratified drift alternate in a 0.5-1.0 m thick zone. The stratified drift consists of horizontal beds of gravelly sand, gravel and stony gravelly sand. It is infiltrated with silt and is very hard. The colour is brown.

A number of clastic dikes (Dionne & Shilts 1974) occur in the till and, except for in one case, they penetrate the underlying stratified drift. Two of the dikes are shown in Figs. 78 and 79. The dikes occur in a 30 m long section which is orientated at 140-320° and faces the west. They do not occur in a 45 m long, south-facing section orientated at 75-225°. The dikes taper downward, dip 45-90° toward the south and strike at 70-250°. The smallest dikes are 5-20 cm wide and 1.5 m deep. The largest ones are up to 2.5 m wide and at least 4.0-5.5 m deep. Only a minimum depth can be given, since the pit-wall in which the dikes were observed is covered by scree 4.0-5.5 m below the surface of the till. Two of the largest dikes which penetrate all of the till bed were traced for 9 and 18 m respectively in the horizontal plane. The dikes consist of sandy till with bodies of sand without visible lamination or with diffuse lamination and strata of sand with distinct lamination. I describe below two of the dikes in further detail.

The dike in Fig. 78 is funnel-shaped just below the surface of the till and consists here of sandy till with thin beds and irregular bodies of sand. The lower part of the

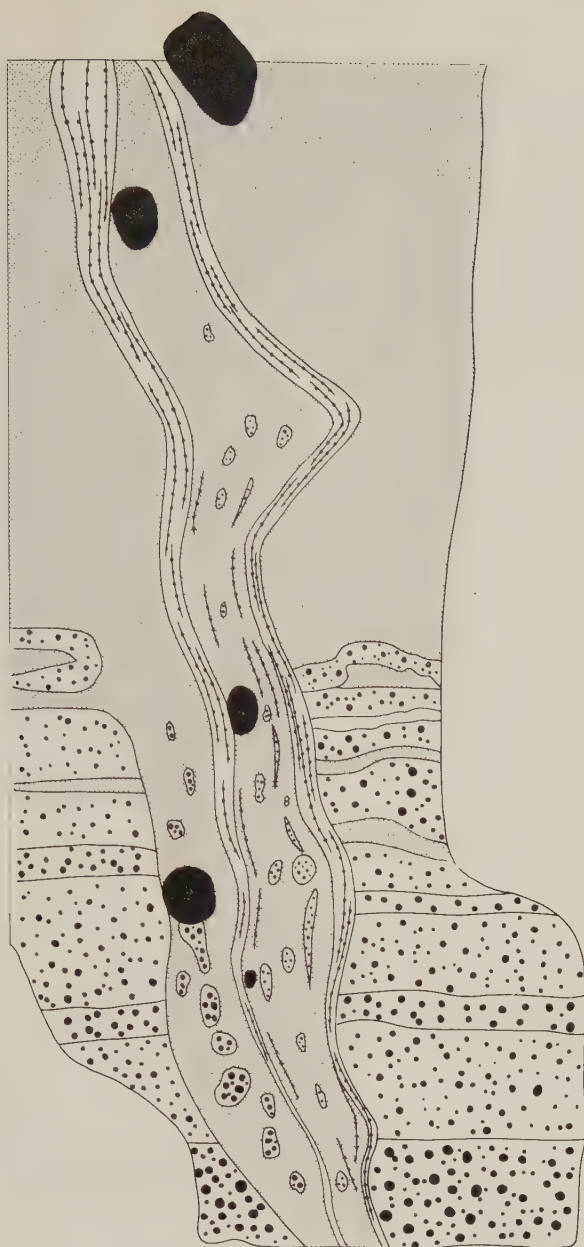


Fig. 79. Clastic dike at site 130. The dike occurs in a section that is orientated at 140–320° and faces the west.

dike dips about 45° toward the south and consists of 3–10 cm thick beds of sand. Fractures and thin beds of sand trending parallel to the dike occur in the surrounding till.

The dike in Fig. 79 dips 80° toward the south, is 90 cm wide and at least 5.5 m deep. It penetrates all of the 2.8 m thick till bed here and was excavated 2.7 m down

in the stratified drift. The boundaries between the dike and the surrounding gravelly sand are distinct. The dike consists of sandy till with bodies and strata of yellowish sand. In the lower part of the dike, the till contains lumps of the surrounding brown, gravelly sand. The bodies of yellowish sand are irregular and diffusely delimited from the surrounding till. Only the largest ones are marked in Fig. 79. The strata of yellowish sand are extended parallel to the boundaries of the dike and are as much as 25 cm thick. The sand displays flat lamination which is mainly distinct.

Discussion – The dikes were filled with drift which must have come from above, since it was possible to observe that most of them taper downward. Further on, the parts of the dikes that penetrate the gravelly sand are filled with till from overlying till bed. The distinct boundaries of the dikes indicate that the drift constituting the dikes filled in fractures formed when the till and the underlying stratified drift were subjected to tension. The strata of sand indicate that the fractures were widening during the infilling of the stratified drift.

I consider that the tension in the till and the underlying stratified drift was caused by an active ice sheet, since clastic dikes resembling the ones at site 130 are thought to have formed in this way (Dreimanis 1969; Mörner 1972; Dionne & Shilts 1974; Humlum 1978). It is not likely that the tension was caused by mass movement, since the till bed is horizontal. The dikes are not ice wedge casts, as high-angle faults and downbent strata are not found in connection with them and they do not form a polygonal pattern. The dip and the strike of the dikes indicate that they were formed when an ice movement from the north-northwest or more exactly from 340° prevailed. The laminated sand in the dikes show that meltwater occurred at the base of the ice sheet during their formation.

7.2.3 The dispersal of boulders from the hill of Kjugekull

Description

Kjugekull is situated immediately west of the southern part of Ivösjön Lake (Plate 1). The hill trends northwest-southeast, is 1 km long, 200 m wide and up to 25 m high (Fig. 80). It is made up of granite and to some extent covered by till. It is probable that the gneiss bedrock is also exposed 400 m south-southwest of and 800 m south of Skiparyd (Fig. 80A). Parts of the hill have vertical or steeply dipping sides (Fig. 80C). The hill is surrounded by Cretaceous limestone which is exposed along the shoreline of Ivösjön Lake (G. De Geer 1889b) and is indicated below an about 5 m thick till bed in two well bore logs. The till is sandy and in the northern part of the investigated area covered by sand, varved clay and peat (G. De Geer 1889b).

Boulders of the sizes considered in this investigation (see below) have not been removed from the pasture land surrounding Kjugekull. However, boulders may have been removed from the cultivated land. The size of the boulders was estimated by measuring along three perpendicular axes. Parts of the boulders are often embedded in the till and it was generally only possible to measure the full length of two axes. The position of all boulders with at least two axes longer than



Fig. 80. The dispersal of boulders from the hill of Kjugekull. A. The occurrence of boulders with an intermediate axis longer than 4 m at and around Kjugekull. B. The morphology of the area covered by Fig. 80A. The contour interval is 5 m and bedrock exposures are indicated. C. Vertical or steeply dipping bedrock surfaces at Kjugekull. Figure 80C is based on the map 'Svenska orienteringsförbundets fritidskarta, Lär-o-karta, Skåne, Juli -77'.

2 m was marked on the Economical Map. The boulders were grouped into four classes depending on the length of the intermediate axis: 2-3 m, 3-4 m, 4-5 m and larger than 5 m.

The mapping showed that boulders with a 2-3 m long intermediate axis occur everywhere in the till-covered part of the investigated area. Boulders with a 3-4 m long intermediate axis occur primarily at and south of Kjugekull but are also found in the rest of the area. Boulders with a more than 4 m long intermediate axis occur almost exclusively at and south of Kjugekull (Fig. 80A). The concentration of these boulders is greatest immediately south of the hill. It was observed that the boulders were released from the bedrock along tectonic fractures. On the northeast side of the hill, boulders are rare where the exposed bedrock surface is even but are common where the bedrock surface is irregular.

Three tail-formed concentrations of boulders were found at the southwest and southeast sides of the hill. They trend north-south and are about 20 m long.

Discussion

The boulder train south of Kjugekull indicates an ice movement from 0-10°, i.e., roughly from the north. Boulders occur west of the northwestern part and south of the southeastern part of the hill. However, it is likely that the granite continues below the till some distance toward the northwest and the southeast. Thus, also the positions of these boulders may be explained by an ice movement from the north.

7.2.4 Seismic investigations

The location of the seismic profiles are shown in Figs. 73 and 74. The seismic graphs are reproduced in Fig. 81.

S5 - V1 = 360 m s⁻¹. V2 = 1050 m s⁻¹. V3 = 4500 m s⁻¹. X1 = 7.5 m. X2 = 27.6 m. V1r = 450 m s⁻¹. V2r = 1500 m s⁻¹. V3r = 4500 m s⁻¹. X1r = 10.2 m. X2r = 36.0 m. D1 = 3.0 m.

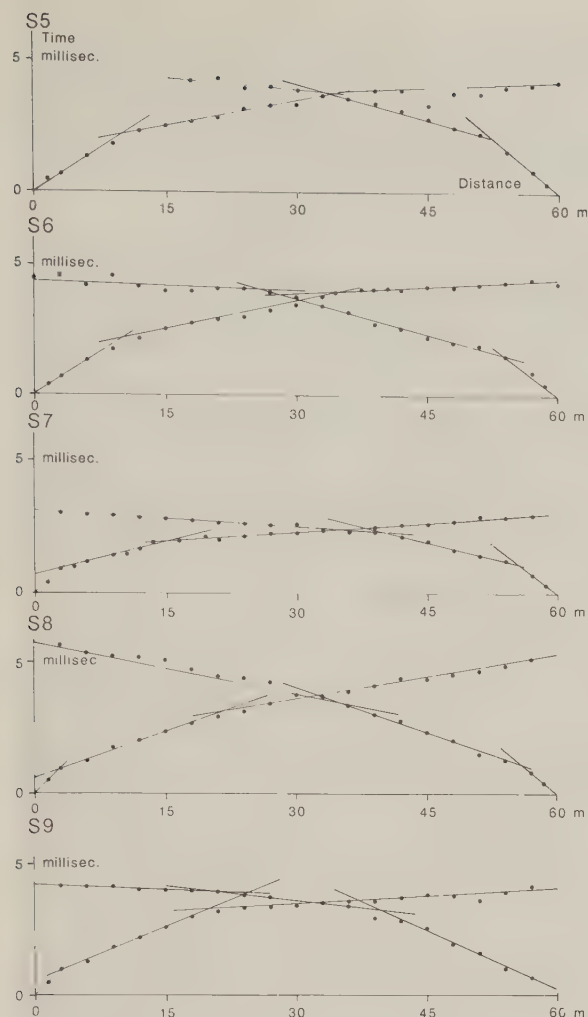


Fig. 81. Seismic profiles. The location of the profiles is indicated in Figs. 73 and 74.

D2 = 13.2 m. D1r = 3.6 m. D2r = 18.3 m. Till occurs in the ground surface. Interpretation: Ground water is indicated about 3 m below the ground surface. An about 15 m thick bed of till with underlying crystalline bedrock occur.

S6 - V1 = 450 m s⁻¹. V2 = 1350 m s⁻¹. V3 = 4500 m s⁻¹. X1 = 10.2 m. X2 = 35.1 m. V1r = 390 m s⁻¹. V2r = 1050 m s⁻¹. V3r = 4500 m s⁻¹. X1r = 6.0 m. X2r = 34.5 m. D1 = 3.6 m. D2 = 16.5 m. D1r = 2.1 m. D2r = 22.8 m. Till occurs in the ground surface. Interpretation: Ground water is indicated about 3 m below the ground surface. An about 20 m thick till bed with underlying crystalline bedrock occur.

S7 - V1 = 315 m s⁻¹. V2 = 1200 m s⁻¹. V3 = 4200 m s⁻¹. X1 = 3.0 m. X2 = 16.5 m. V1r = 390 m s⁻¹. V2r = 1200 m s⁻¹. V3r = 4500 m s⁻¹. X1r = 4.5 m. X2r = 19.5 m. D1 = 1.1 m. D2 = 7.2 m. D1r = 1.6 m. D2r = 8.9 m. Till occurs in the ground surface. Interpretation: Ground water is indicated at slightly more than 1 m below the ground surface. An about 8 m thick till bed with underlying crystalline bedrock occur.

S8 - V1 = 300 m s⁻¹. V2 = 840 m s⁻¹. V3 =

1680 m s⁻¹. X1 = 3.0 m. X2 = 22.5 m. V1r = 420 m s⁻¹. V2r = 900 m s⁻¹. V3r = 1500 m s⁻¹. X1r = 3.5 m. X2r = 25.5 m. D1 = 1.1 m. D2 = 7.1 m. D1r = 1.3 m. D2r = 7.4 m. Till occurs in the ground surface. Interpretation: Ground water is indicated about 1 m below the ground surface. Till occurs to about at least 7 m below the ground surface.

S9 - V1 = 300 m s⁻¹. V2 = 720 m s⁻¹. V3 = 4500 m s⁻¹. X1 = 3.0 m. X2 = 19.5 m. V1r = 660 m s⁻¹. V2r = 2700 m s⁻¹. V3r = 5400 m s⁻¹. X1r = 21 m. X2r = 39 m. D1 = 1.0 m. D2 = 8.9 m. D1r = 8.1 m. D2r = 17.1 m. Till occurs in the ground surface. Interpretation: Ground water is indicated about 5 m below the ground surface. A till bed on the average about 11 m thick underlain by crystalline bedrock occur.

7.3 Glaciofluvial deposits

The glaciofluvial deposits on the plain around Kristianstad form north-south to north-north-east - south-southwest trending zones (Plate 1). They are made up mainly of gravelly sand and sand. The gravelly sand occurs in the central parts of the zones and is surrounded by sand. The stratified drift is rather often covered by varved clay and beach deposits. However, Nilsson & Gustavsson (1967), K. Nilsson (1968) and Gustavsson et al. (1979) have by compilations of well bore logs determined the extent of the buried stratified drift. Plate 6 which shows the glaciofluvial deposits on the plain around Kristianstad is based on their work and Plate 1. I describe below the largest zones with glaciofluvial deposits and some of the exposures occurring in them.

7.3.1 The Lyngsjö - Bjärlöv deposits

General description

The Lyngsjö - Bjärlöv deposits (Rydenheim 1973: the Helge esker) form a roughly north-south trending zone. Between Lyngsjö and Vä, the deposits are located in a depression that is about 1 km wide and 10 m deep. The floor of the depression slopes toward the south, south of a point located 1 km south of Vä and toward the north-northwest north of this point. North of Färlöv, the deposits are found in a valley that is 1-2 km wide, 5-35 m deep and has a southward-sloping floor. Well bore logs show that the Cretaceous bedrock surface is located 7-12 m below the valley floor.

Mounds of sand, often with an irregular surface constitute the glaciofluvial deposits south of Lyngsjö. The mounds are 100-500 m in diameter, 5-10 m high and their top surfaces reach 30-45 m a.s.l. Depressions of varying size occur between the mounds.

The gravelly stratified drift between Lyngsjö and Vä reaches about 30 m a.s.l. and form ridges and some mounds. The ridges are entirely or largely covered by sand. A ridge of stony gravelly sand that is entirely covered by sand occurs at site 131. Only the crest of the ridge 3.5 km south-southwest of Vä is visible. The ridge is continuous, winding and about 800 m long. A gravel-pit in the ridge (site 132) shows horizontally-bedded stony gravelly sand. The ridge 2.2 km south-southwest of Vä is at least 450 m long and protrudes some meters above the surrounding ground surface. The ridge 500 m south of Vä

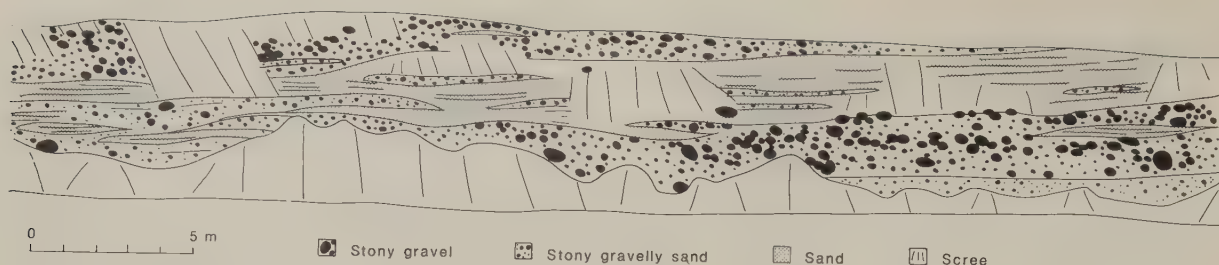


Fig. 82. A longitudinal section in the ridge of stratified drift at site 131. The section is orientated at 10-190° and faces the west.

is 600 m long and is partly covered by sand. The mounds are 100-200 m in diameter and less than 5 m high.

From 1 km south of Färlöv to Bjärlöv, the stony gravelly sand and gravelly sand reach 15-25 m a.s.l. and form mounds that are 100-500 m in diameter and rise up to 10 m above the surrounding sandy deposits with an even surface. Pits in the mounds 3 km north of Färlöv show horizontal beds of stony gravelly sand alternating with beds of sand. Some beds of stony gravel were also observed here. G. De Geer (1889b) observed in an exposure immediately east of Bjärlöv that the gravel occurring here is located in an elongated depression in the underlying till.

A 5-10 m high plateau of gravelly sand with a diameter of 400 m occurs immediately north of Bjärlöv. North of this plateau, the gravelly stratified drift reaches 30-45 m a.s.l. and forms ridges and mounds of varying length and diameter. The ridges consist of stony gravelly sand. A gravel-pit in a 7 m high mound with a diameter of 200 m shows horizontally-bedded sand in which beds of stony gravelly sand occur (site 133).

Exposures

Site 131 - A 500x500 m large area with several sand and gravel-pits that are up to 7 m deep. The surrounding ground surface is even and reaches 30-35 m a.s.l. In the central part of the area, a north-south trending ridge of till is exposed, the surface of which slopes gently toward the west and the east. A mound of till protruding slightly above the surrounding sand is located immediately north of the area.

In the northeastern part of the pit area, a ridge is cut lengthwise by a 90 m long and 5 m high section, orientated at 10-190° and facing the west. The ridge east of the section is almost entirely covered by sand. Only the uppermost part of the crest is visible. The section, a part of which is shown in Fig. 82, displays beds of stony gravel, stony gravelly sand and sand dipping 3-5° toward the north. Boulders and stones are rounded. Trough cross-lamination and flat lamination occur in coarse and medium sand and ripple lamination in medium and fine sand. The trough cross-lamination and the ripple lamination (xy plane: type A, yz plane: troughs and xy plane: type B, yz plane: troughs) indicate a paleocurrent from the north. Beds of fine-sandy silt and silt occur in the sand. Some laminae of clay were observed in the silt.

In the northeastern part of the pit area, about 150 m west of the above-described section, a 30x20 m large and 3 m deep cut is found in the pit-floor. The walls in the cut

display a lower, 2.5 m thick unit consisting of folded gravelly stratified drift which is separated by a discordance from an upper, 0.5 m thick unit with varved clay and sand. Alternating beds of stony gravelly sand, gravelly sand, sand, silt and strata of clay make up the lower unit. Flat lamination is common in the gravelly sand. The clay is reddish-brown or grey and forms 0.4-3.0 cm thick strata that occur mainly in beds of fine sand and silt. The folds are overturned, the axial planes dip toward the north and the fold axes trend east-west. The discordance cuts off the upper parts of the folds and lies in the same plane as the gently eastward-dipping pit-floor. The varved clay in the upper unit is laminated parallel to and rests directly on the discordance. The clay is reddish brown and 40 varves were measured. The varved clay passes gradually upwards in ripple-laminated fine sand with laminae of clay.

The majority of the pits in the area are located in sandy beach deposits which are underlaid by a bed of varved clay consisting of 10-40 varves. The varved clay passes gradually upward into a 0.5-2 m thick bed of ripple-laminated silty fine sand and medium sand with laminae of clay. The ripples (Fig. 83A) often have straight crests, are symmetrical and draped with laminae of clay. They resemble wave ripples described by Reineck & Singh (1975). The ripple-laminated sand is overlaid by a 3-6 m thick bed of sand and gravelly sand with tabular cross-lamination. The laminae are curved, dip about 25° in the upper part of the bed and 5-10° in the lower part. They dip toward the north, strike between 70-250° and 100-280°, and, consequently, indicate paleocurrents from the south.

Site 132 - A 200 m long, 35-50 m wide and 2-6 m deep gravel-pit located in a roughly north-south trending ridge. The ridge is completely removed in the northern, 50 m wide part of the pit, which indicates that the ridge is about 50 m wide. It consists of up to 2 m thick beds of stony gravelly sand and sand that are as much as 50 m long parallel to the long axis of the ridge. The beds are horizontal and undisturbed in the central and western parts of the ridge but are steeply dipping and deformed in the eastern part. Stones and boulders are rounded. The sand is mainly flat-laminated or trough cross-laminated. The cross-lamination indicates a paleocurrent from the north.

Site 133 - A 200x150 m large pit located in a mound. Only the southwestern part of the mound remains. Here, a 130 m long and 5-6 m high section occurs, a part of which is shown in Fig. 84. The bedding is sub-horizontal and sand predominates. A 50 m long and 0.3-

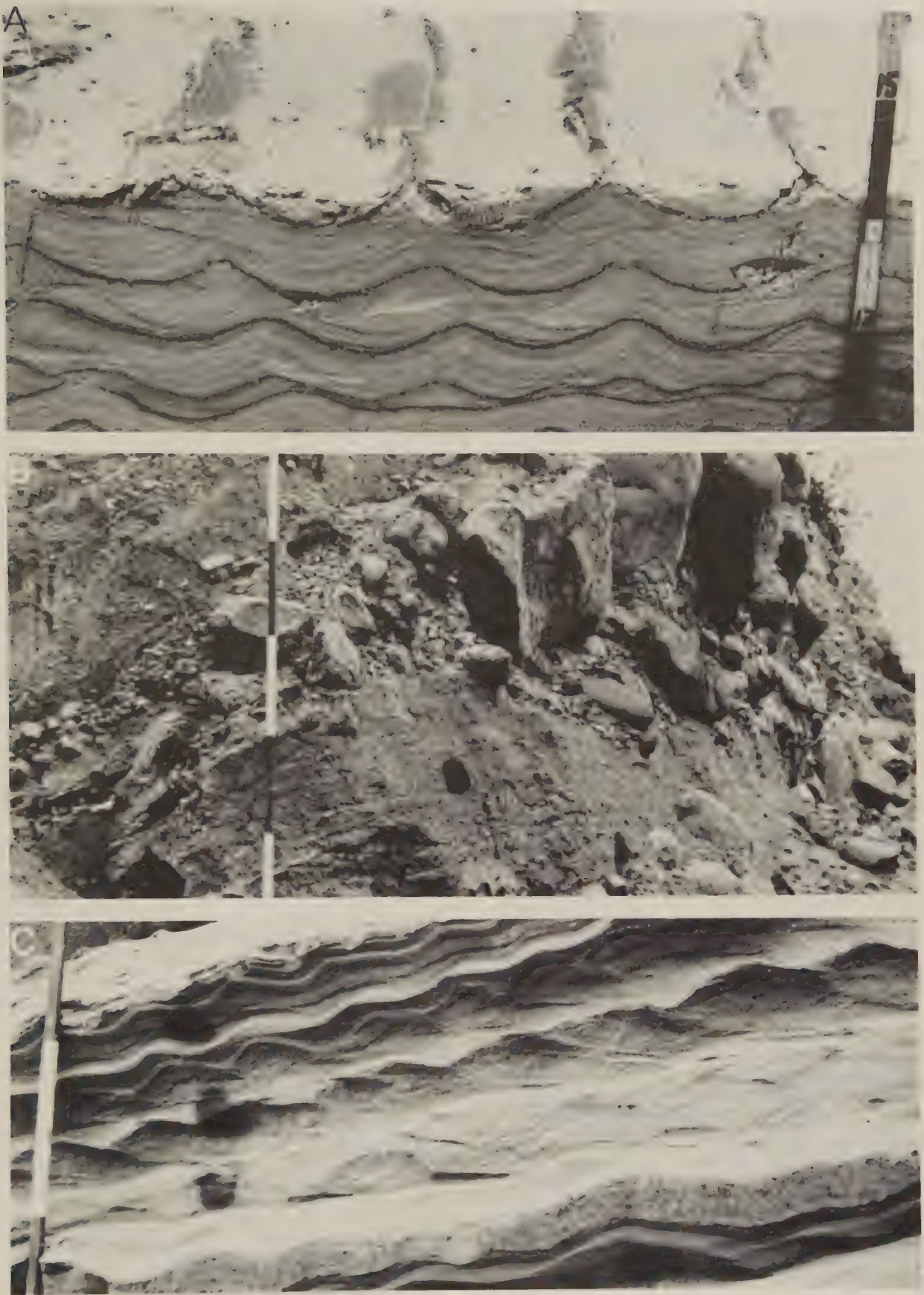


Fig. 83. Beach deposits and stratified drift on the plain around Kristianstad. A. Wave ripples at site 131. The folding rule is divided into 10 m long sections. B. Bed of flat-laminated gravelly coarse sand overlaid by a bed of stony gravel in the lower part of section 18-19 at site 140 (Fig. 89). The rod is divided into 25 ca long sections. C. Bed of ripple-laminated fine and medium sand in section 12-13 at site 140 (Fig. 89). The rod is divided into 25 cm long sections.

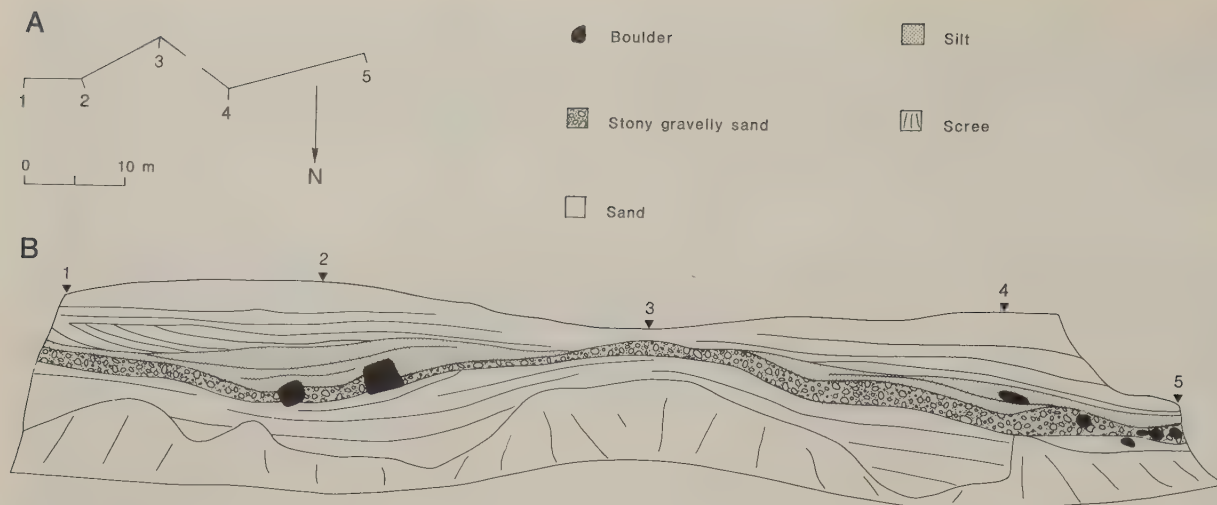


Fig. 84. A part of a section in a mound of stratified drift at site 133.

1.1 m thick bed of stony gravelly sand is found. It is overlaid by an up to 1.5 m thick bed of silt with laminae of clay. Flat lamination and ripple lamination are common in the sand. Trough and planar cross-lamination also occur. The ripple lamination (xy plane: type A and B) indicates a paleocurrent roughly from the north.

7.3.2 The N. Åsum deposits

The N. Åsum deposits (Rydenheim 1973: the N. Åsum deposits) reach 5–15 m a.s.l. and form a roughly north-south trending zone. The southern part of the zone is surrounded by less than 10 m high heights covered by or made up of till. At N. Åsum, some pits displaying sandy stratified drift occur. Silt with laminae of clay are found in the sand.

7.3.3 The Råbelöv deposits

General description

The Råbelöv deposits (Rydenheim 1973: the Råbelöv esker) reach 5–35 m a.s.l. and are located in a north-south trending valley that is about 1 km wide and has a southward sloping floor. The difference in height between the valley floor and the till-covered areas west of the valley is less than 10 m. The area east of the valley reaches about 15 m above the valley floor, except for east of Fjälkestad, where the hill of Balsberget rises 50 m above the floor. Well bore logs show that the Cretaceous bedrock is located 10–15 m below the valley floor.

The gravelly deposits from 1.5 km south of Fjälkestad and southward are largely covered by sand. About 1.5 km south of Råbelöv, the deposits form a 350 m long ridge that protrudes some meters above the surrounding sand. Site 134 is located in the central part of a mound of gravelly sand that is about 400 m in diameter. Immediately north of and merging with this mound is another mound that is elongated in a north-south direction. It is about 400 m long and 200 m wide.

From 1.5 km south of Fjälkestad and northward, the stony gravelly sand is formed into ridges and mounds. The two ridges south of Fjälkestad are separated by an elongated mound. The southern ridge is about 300 m

long and the northern, about 600 m long. The ridges and the mound protrude a couple of meters above the surrounding sand. The ridges have triangular cross-sections, are about 50 m wide and 5 m high.

Exposures

Site 134 – A 200x100 m large and up to 12 m deep sand-pit. The pit-walls are covered by scree except for in the northern part of the pit, where the upper 2–5 m are exposed in two 70 m long sections. One section is orientated at 0–180° and faces the east. The other is orientated at 70–250° and faces the south. Sand with up to 1 m thick beds of stony gravelly sand and 0.3–0.5 m thick beds of silt occurs in the sections. Some clay laminae were observed in the silt. The beds are horizontal or gently dipping in the western section. In the northern section, both horizontal and steeply-dipping beds occur. Flat lamination and ripple lamination are common in the sand. The ripple lamination (xy plane: type A, yz plane: troughs) indicates a paleocurrent from about the north.

7.3.4 The Balsby deposits

General description

The Balsby deposits (Rydenheim 1973: The Balsby esker) reach 20–30 m a.s.l. and are situated south of a northwest-southeast trending depression that is 1 km long, 500 m wide and 10 m deep.

A north-northwest – south-southeast trending ridge is found at Balsby. It has rather gently sloping sides, is 1 km long, 200 m wide and about 5 m high. A gravel-pit (site 136) shows that the ridge consists of a central part with stony gravelly sand that is surrounded by sand. In the southern part of the pit, stony gravelly sand alternates with sand. Here, the ridge also widens toward the south and merges into the deposits of sand south of Balsby. These deposits have a horizontal surface. The pits here display horizontally-bedded sand which sometimes is gravelly and contains beds of silt. In some of the silt beds, laminae of clay were observed. Trough cross-lamination and ripple lamination indicate paleocurrents from between

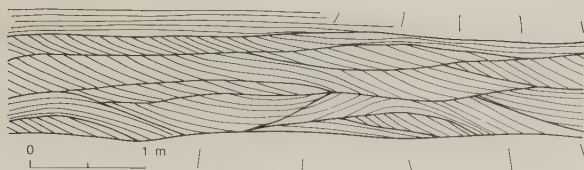


Fig. 85. Through cross-lamination and flat lamination in sand at site 136. The section is orientated at 25-205° and faces the west.

the north and the northeast (site 135).

Exposures

Site 135 - A 200x100 m large and 3-4 m deep sand-pit. The sand is slightly gravelly and flat-laminated or trough cross-laminated. Figure 85 shows flat lamination and trough cross-lamination in a section located in the southern part of the pit. The section is orientated at 25-205° and faces the northwest. The sets are 0.2-0.4 m thick.

Site 136 - A 300x75 m large gravel and sand-pit. The northern and central parts of the pit are 10 m deep and the pit-walls are largely covered by scree. Stony gravelly sand predominates here. In the southern part of the pit, the stratified drift is composed of sand in which beds of stony gravelly sand occur. Flat lamination and trough cross-lamination are common in the sand. The sand and the stony gravelly sand are overlaid by an about 0.4 m thick bed consisting of silt which gradually shifts upward into fine sand. In the silt bed, 24 laminae of greyish or brownish clay occur. The bed is overlaid by a 1.5-2.5 m thick bed of beach sand. The beach sand is horizontally bedded and ripple laminated (xy plane: type A, yz plane: troughs). The sets are not climbing but are parallel to the bedding planes and indicate mainly paleocurrents from about the east and the west.

7.3.5 The Åhus - Kiaby deposits

General description

The Åhus - Kiaby deposits (Rydenheim 1973; the Oppmanna esker) form a roughly north-south trending zone. The central part of the zone curves toward the east along the heights west and north-northwest of Nymö. These heights rise less than 10 m above the surrounding, horizontal ground surface except for north-northwest of Nymö, where the hills of Fjälkinge backe and Lilles backe are situated. Fjälkinge backe is located 5.5 km north-northwest of Nymö and reaches 65 m above the surrounding ground surface. Lilles backe is situated 3.5 km north-northwest of Nymö and rises 30 m above the surrounding ground surface.

According to Gustavsson et al. (1979), the Cretaceous bedrock surface slopes toward the west beneath the glaciofluvial deposits south of Nymö (Fig. 86, Plate 6). At Nymö, the deposits are located in a depression. North-northwest of Nymö, they are situated on an eastward sloping bedrock surface. Well bore logs show that the stratified drift in the central part of the zone with glaciofluvial deposits rests directly on the bedrock, whereas the surrounding stratified drift is underlain by till (Gustavsson et al. 1979).

Between Åhus and 5 km south-southwest of



Fig. 86. The relation between the Cretaceous bedrock surface (Gustavsson et al. 1979) and the glaciofluvial deposits east of Kristianstad. The contour interval is 10 m.

Nymö, the glaciofluvial deposits are often covered by varved clay which is overlaid by beach sand. Between 5 km south-southwest of and 2 km north of Nymö, the deposits reach the ground surface. The surface is located 10-15 m a.s.l., is horizontal and coincides with the surface of the surrounding beach sand which is underlain by varved clay. Well bore logs show that the stratified drift between Åhus and 2 km north of Nymö is 20-55 m thick and is predominated by sand. In the pits occurring here, Rydenheim (1973) observed that the sand contains beds of silt and sometimes is gravelly.

The deposits reach up to 35 m a.s.l. between 2 km north of Nymö and Kiaby. Their surface is even and slopes gently toward the east. At site 129, they are made up of stony gravelly sand and sand.

The stratified drift northwest of Kiaby reaches 25-40 m a.s.l. and forms a plateau with mainly gently sloping sides. The top surface of the plateau is undulating or even. It is horizontal, except in the north where it slopes toward the north. The deposits are at least 15 m thick and are predominated by gravelly sand. The sand is mainly horizontally bedded and contains beds of stony gravelly sand and silt.

The stratified drift northwest of Kiaby reaches 25-40 m a.s.l. and forms a plateau with mainly gently sloping sides. The top surface of the plateau is undulating or even. It is horizontal, except in the north where it slopes toward the north. The deposits are at least 15 m thick and are predominated by gravelly sand. The sand is mainly horizontally bedded and contains beds of stony gravelly sand and silt.

Exposures

Site 129 - See description in Chapter 7.2.2.

Site 130 See description in Chapter 7.2.2.

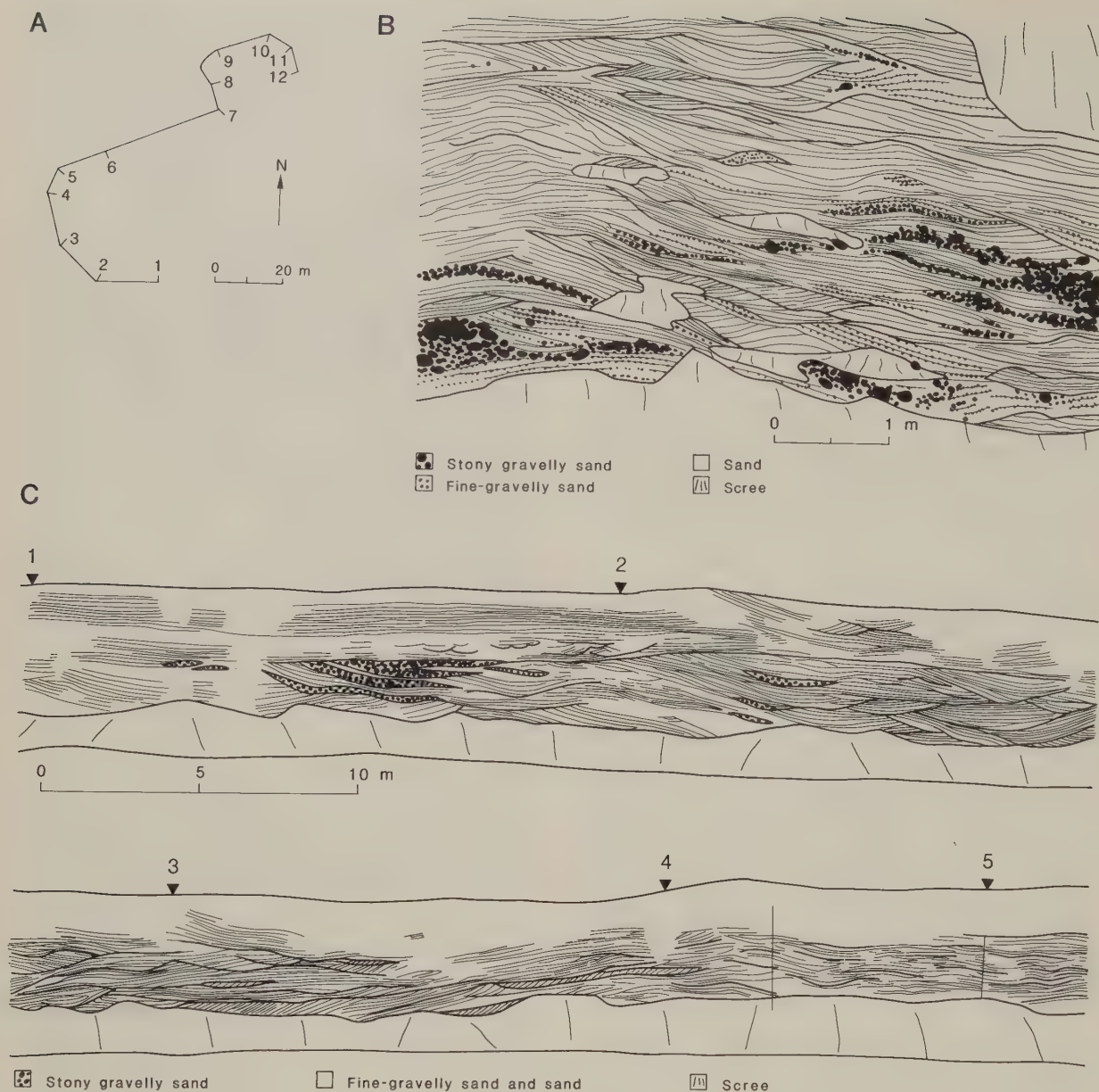


Fig. 87. The sand-pit at site 138. A. Map of the pit. B. Flat-laminated and trough cross-laminated sand with beds of stony gravelly sand in a part of section 7-8. C. Trough cross-lamination and flat lamination in section 1-5.

Site 137 - A 60x30 m large and 10 m deep sand-pit. The sand is horizontally bedded and contains beds of silt in which some laminae of clay were observed. Flat lamination, trough cross-lamination and ripple lamination occur in the sand. The trough cross-lamination and the ripple lamination (xy plane: type A, yz plane: troughs and xy plane: type B, yz plane: troughs and parallel lamination) indicate a paleocurrent from about 45°.

Site 138 - A 100x80 m large and 5-10 m deep sand-pit. Sand with varying amounts of fine gravel predominates (Fig. 87). Horizontal and 0.1-1 m thick beds of stony gravelly sand occur. The sand is mainly flat-laminated or trough cross-laminated. The beds with flat lamination are 0.2-1.5 m thick and the trough sets are 20-80 cm thick. The trough cross-lamination indicates a paleocurrent from on an average 45°.

Site 139 - A 200x100 m large and 8 m deep sand-pit. The pit-walls are mainly covered by scree except in the northern part of the pit. Here, horizontal bedding is found in a cut in the pit-floor and in a 150 m long section, a part of which is shown in Fig. 88B. The cut is 4 m deep and 20 m in diameter. Sand with a varying amount of fine gravel predominates here. In the sand, 10-50 cm thick and 1-4 m long beds of stony gravelly sand occur (Fig. 88C). The sand is flat-laminated. The trough sets are 10-30 cm thick and indicate a paleocurrent from on an average 45°. In the 120 m long section, 5-30 cm thick and 1-5 m long beds of alternating coarse and medium sand with flat lamination and fine and medium sand with ripple lamination occur. Laminae of silty clay are found in the fine and medium sand in the upper part of the section.



Fig. 88. Stratified drift at site 139. A. Map of the southern part of the pit. B. Bedding in section 1-5. C. Close-up of beds of sand with flat lamination and beds of stony gravelly sand in a cut in the pit-floor.

Site 140 - This site is made up of two gravel-pits (Fig. 89A). The northern pit is 200x140 m large and 7-10 m deep. The southern pit is 160x120 m large and 5-15 m deep. In parts of the pits, the gravelly stratified drift is overlaid by varved clay and beach deposits (Fig. 89B).

The bedding in the stratified drift is mainly horizontal or gently dipping and undisturbed. However, deformed or steeply-inclined beds occur in the southern pit. The stratified drift in section 10-11 is irregularly folded. The folds are cut off at the points of contact with the overlying varved clay. A large number of high-angle faults occur along with the steeply-dipping beds in the southern part of section 12-13. The faults indicate that a local lowering of the stratified drift has taken place here. In section 16-17, the stratified drift and the overlying varved clay are gently folded. The fold axes trend roughly east-west and the folds in the upper part of the bed are discordantly cut off. The beds in the eastern part of section 18-19 and the western part of section 19-20 dip up to 50° toward the north.

Beds of stony gravel, stony gravelly sand, coarse and medium sand with a varying content of gravel and fine and medium sand alternate (Figs. 83B and 89C). The beds are 0.1-1.5 m thick and 2-20 m long. Mainly flat lamination but also trough cross-lamination occur in the gravelly coarse and medium sand. The trough sets are 20-50 cm thick. In the fine and medium sand, which sometimes is silty, ripple lamination is common (Fig. 83C). The ripple lamination (xy plane: type A, yz plane: troughs and xy plane: type B, yz plane: troughs and parallel lamination) and the trough cross-lamination indicate paleocurrents from 0-50°. In the silt beds, 0.5-3.5 cm thick strata of reddish-brown clay occur.

Beds of stony gravel are above all found in section 18-20 in the southern pit. Silt beds are more common in the eastern and western parts of the pit than in the central part. They are often more numerous in the upper parts of the sections than in the lower

parts.

Varved clay overlies the stratified drift in section 10-11 and 16-17 in the southern pit. In section 10-11, the varved clay forms a 20 cm thick bed containing 10 varves. The winter laminae are reddish-brown and the summer laminae are grey. In section 16-17, a 40 cm thick bed of varved clay and silt with clay laminae occur. The colour of the clay is the same as in section 10-11.

Beach sand overlies the varved clay in section 10-11 and 16-17 in the southern pit. In section 10-11, it forms a 2.5 m thick bed. The lower and 0.5 m thick part of the bed consists of horizontally-bedded medium and fine sand in which 15 laminae of clay occur. Ripple lamination here indicates a paleocurrent from about the west. The upper part of the bed consists mainly of coarse sand making up beds dipping 10-20° toward the east. Only in the north-northeast - south-southwest trending part of section 10-11 are these beds cut nearly parallel to their true dip. In section 16-17, the beach sand forms a 2 m thick bed with horizontal bedding. Ripple lamination indicates a paleocurrent from about the east.

7.3.6 The Gualöv deposits

General description

The Gualöv deposits (Rydenheim 1973: the Gualöv esker) form a north-northeast - south-southwest trending zone, parts of which are covered by varved clay and beach sand. Where the stratified drift reaches the ground surface, its surface coincides with or forms an about 300 m wide ridge that rises a couple of meters above the surrounding beach sand. The deposits reach up to 10-15 m a.s.l. The stratified drift in the central part of the zone rests directly on the bedrock (Gustavsson et al. 1979) and in a north-northeast - south-southwest trending depression in the bedrock (Fig. 86). The deposits are predominated by sand that often is 20-40 m thick.

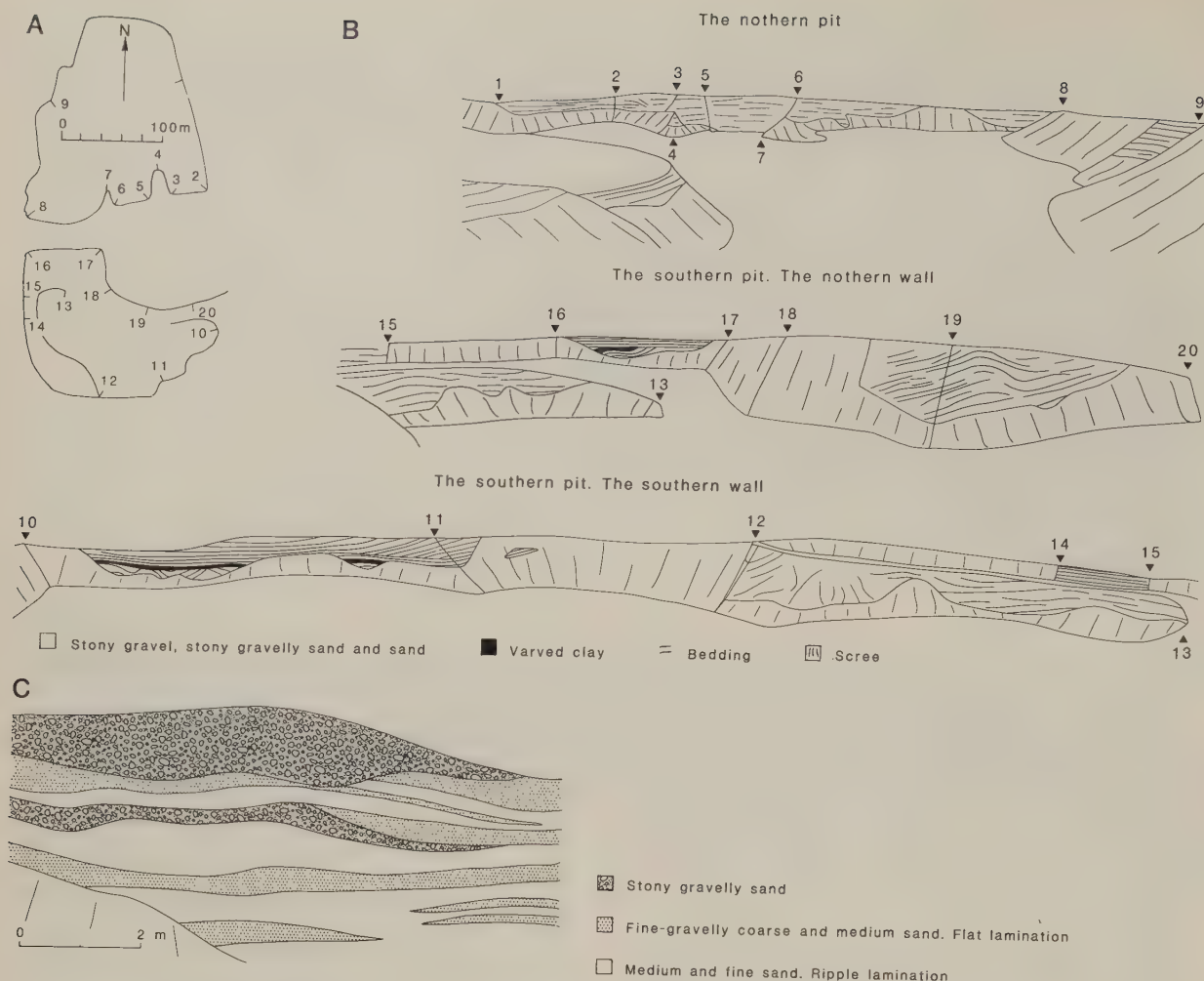


Fig. 89. The gravel-pits at site 140. A. Map of the pits. B. Bedding in section 1-9 in the northern pit and section 1-20 in the southern pit. C. Close-up of the bedding in the central part of section 12-13 in the southern pit.

Exposures

Site 141 - A 150x80 m large and 7 m deep sand-pit. The pit-walls are largely covered by scree. In the southern part of the pit, a 4x2 m large, vertical surface, orientated at 170-250° and facing the east, shows sand with ripple lamination. Laminae of silt and nine laminae of reddish-brown clay occur in the sand. The ripple lamination (xy plane: type A and B) indicates a paleocurrent roughly from the north.

7.3.7 The glaciofluvial deposits on the peninsula of Listerlandet

North of a line crossing Mjällby on the peninsula of Listerlandet, the till and bedrock surface is gently undulating.

Glaciofluvial deposits consisting of stony gravelly sand and gravelly sand protrude at some places above the sand that covers a large part of the peninsula. Some of the sand is of glaciofluvial origin and some is beach sand underlain by varved clay. The visible parts of the gravelly deposits reach 5-10 m a.s.l. and have horizontal surfaces, apart from a north-northeast - south-southwest trending ridge 8 km north-northwest of Mjällby. The visible part of the ridge is continuous, 1.8 km long and protrudes up to 5 m

above the surrounding sand.

The deposits 3.5 km west of Mjällby consist of gravelly sand with beds of stony gravelly sand and silt. Stony gravelly sand and sand was observed by Hellberg (1971) in gravel-pits situated in the deposits 4 km northeast of Mjällby. Well bore logs show that the parts of these deposits that are covered by beach sand and varved clay consist of stony gravelly sand and sand.

7.4 Varved clay

Varved clay occurs on the plain around Kristianstad below about 25 m a.s.l. It is exposed mainly around and northwest of Kristianstad on the northern part of the plain and on the peninsula of Listerlandet (Plate 1). However, varved clay is common beneath beach sand all over the plain (Lindström 1877; Antevs 1915; K. Nilsson 1968; Gustavsson et al. 1979; Ringberg 1979). The varved clay rests on till and especially in the southern part of the plain, also on glaciofluvial deposits.

The varved clay is usually between 0.5 and 6 m thick (Lindström 1877; G. De Geer 1889b). The proximal varves are 1-68 cm thick and the distal varves are a few millimeters to 3 cm thick (Ringberg 1971, 1979). The

winter layers are some millimeters thick, contain more than 60% clay and are reddish brown (Ringberg 1979). The summer layers consist of silt and sand in the proximal varves. In the distal varves, the summer layers are made up of silt or grey clay containing more silt than the clay in the winter layers. At a site located 300 m north-northeast of Gualöv, Ringberg (1971) showed that the deposition of the silt making up the summer layer in a 68 cm thick proximal varve lasted about 56 days. Thin beds and laminae of coarse silt alternating with thin beds and laminae of medium silt and fine silt and millimeter-thick laminae of clay constitute the measured summer layer. The winter layers at the site are 1.5–2.0 cm thick and consist of clay.

Antevs' (1915) and Ringberg's (1979) varve chronological investigations showed that the ice sheet receded toward the north and that the ice margin trended east-west in the area around and north of Kristianstad. Ringberg's recession lines are shown in Plate 6.

7.5 Beach deposits

Beach deposits are common on the plain around Kristianstad up to 50–60 m a.s.l. A large part of the sand on the plain that occurs between and in part overlies the glaciofluvial deposits marked in Plate 6 make up beach deposits.

G. De Geer (1889b) stated that the beach deposits reach the following highest levels on the northern part of the plain (Plate 1): 50.5 m a.s.l. 2 km north-northeast of Bjärlöv; 52.8 m a.s.l. 2.5 km east-southeast of Fjälkestad; 55.5 m a.s.l. 5 km south of Vånga; 53.8 m a.s.l. on the island of Ivön; at least 52.0 m a.s.l. on the hill of Kjugekull. The deposits consist of stony gravelly sand which often forms up to about 1 m high beach ridges.

Hellberg (1971) investigated the beach deposits on the island of Hanö and on the southern sides of the drumlin-shaped hills on the peninsula of Listerlandet (Plate 1). She found that beach ridges and bench marks are common from about 17 m a.s.l. up to a height that varies between 50.4 and 54.9 m a.s.l. on the individual hills. Above 50.4–54.9 m a.s.l., the hills rise 6–20 m and are covered by till that is unaffected by wave-washing. The beach ridges are about 1 m high and are made up of stony gravelly sand. On the individual hills, 10–29 beach ridges were observed.

C. Dupuy (in prep.) investigated the beach deposits and the upper limit of wave-washed till on Ivön by mapping and by soil sampling along two lines trending perpendicular to the contour lines. One line was located on the southern side of the drumlin-shaped hill on Ivön and the other on the western side of the hill. The investigation showed that the upper limit of wave-washed till and beach deposits is located at 55 m a.s.l. on the southern side of the hill and at 52 m a.s.l. on the western side.

7.6 The deglaciation of the plain around Kristianstad

7.6.1 The formation of the glaciofluvial deposits

Parts of the glaciofluvial deposits consist of medium sand, fine sand and silt with strata of clay. This and the fact that the varved

clay rather often overlies the glaciofluvial deposits indicate sedimentation in a lacustrine environment. Since the fine-grained stratified drift is interbedded with or gradually merges into stony gravelly sand and gravelly sand, it follows that the deposition took place mainly in the vicinity of the ice margin, where the glaciofluvial meltwater streams entered the lake. Stratified drift with similar grain-size composition and sedimentary structures are considered to have accumulated in lakes at the ice margin by among others G. De Geer (1940), Helm (1971), Banerjee & McDonald (1975), Rust & Romanelli (1975) and Saundersson (1975).

The glaciofluvial sediments making up the ridges accumulated probably immediately inside the ice margin. This is suggested by the ridge at Balsby, which gradually merges into lacustrine deposits (Chapter 7.3.4). The ridges may have formed in a tunnel or in the inner part of an estuary (see below). The deformation of the stratified drift along the eastern side of the ridge at site 132 (Chapter 7.3.1) probably took place when the glacier ice supporting the sides of the ridge disappeared.

The grain-size composition, size and morphology of the mounds indicate that their proximal sides were in contact with the ice margin and that the stratified drift making up the mounds accumulated at most some hundred meters in front of the ice sheet.

The stratified drift constituting the plateau northwest of Kiaby (Chapter 7.3.5) accumulated by gradual stages in a northerly direction, since the grain-size composition of the stratified drift varies in a north-southerly direction and upward-fining sequences occur.

The ice margin may have been straight or formed estuaries (bays) where the glaciofluvial sediments accumulated. The stratified drift making up the eskers in south-central Sweden was often deposited in estuaries: this is indicated by the investigations of G. Lundqvist (1955), Bergdahl (1959, 1963), Magnusson (1970, 1972a, 1972b, 1975) and Fromm (1972). The ice sheet terminated here in standing water and the inner parts of the funnel-shaped estuaries were often very narrow. The estuaries are only revealed where De Geer moraines and glacial striae are frequent in the vicinity of the eskers. Also the stratified drift on the plain around Kristianstad may have accumulated in estuaries. If so, it is possible that the ridges were formed in the inner, narrow part of the estuaries.

7.6.2 The recession and the properties of the ice sheet

Three facts indicate that the meltwater which transported the glaciofluvial sediments flowed along the base of the ice sheet. Firstly, the sediments are located in or on the sides of shallow valleys or depressions. Secondly, the sediments in the central part of the zones with glaciofluvial deposits often rest directly on the bedrock. Thirdly, the horizontal bedding and the lamination in the glaciofluvial deposits indicate meltwater streams flowing along the bottom of the lake in which the sedimentation took place (cf. Chapter 5.6.5).

The silt and the clay constituting the varved clay on the plain around Kristianstad ought to have been transported by meltwater flowing along the base of the ice sheet, since the coarser sediments were transported here. The strata of clay in the glaciofluvial deposits occur along with beds of stony gravelly sand and sand. From the above and from Ringberg's (1971) observation that the silt

making up the proximal varve at Gualöv accumulated during about 56 days in the summer half, one can conclude that the subglacial meltwater discharge varied throughout the year and was high during the summer half and low during the winter half. Consequently, the main part of the meltwater which transported and deposited the glaciofluvial sediments was surface meltwater that penetrated the ice sheet and flowed along its base, since only the production of surface meltwater varies greatly throughout the year (cf. Chapter 5.1.4). This means that the ice sheet was mainly at the pressure melting point at least in a marginal zone when the plain around Kristianstad was deglaciated.

The subglacial meltwater that transported the sediments making up the glaciofluvial deposits around Vå, Balsby and south of Gualöv (Plate 6) flowed in an up-slope direction. Parts of the Åhus - Kiaby deposits are located on the sides of the depressions occurring here (Fig. 86). This is possible to explain if the ice sheet had a sloping surface that controlled the flow of the subglacial meltwater. Consequently, the receding ice sheet was active, which is also supported by the folded stratified drift with strata of clay at site 131 (Chapter 7.3.1). From the above, it follows that the majority of the glacial striae on exposed bedrock surfaces reflect an ice movement near the margin of the ice sheet.

South of an east-west trending line cross-

ing Kristianstad, the bedrock is gently undulating and cannot have controlled the main flow direction of the subglacial meltwater. Consequently, the trend of the zones with glaciofluvial deposits occurring here indicates the direction of slope of the ice surface during the recession of the ice sheet. The margin of the ice sheet ought to have been perpendicular to this direction. This, Ringberg's (1979) recession lines and the glacial striae constitute the basis of the recession lines presented in Fig. 100.

7.6.3 The highest shoreline and water-level changes

The investigations by G. De Geer (1889b), Hellberg (1971) and C. Dupuy (in prep.) show that the highest shoreline in the northern part of the plain around Kristianstad is located at 50-60 m a.s.l. It is uncertain in the southern part of the plain, but the sandy glaciofluvial deposits south of Lyngsjö (Chapter 7.3.1) may indicate a water level at about 45 m a.s.l. during the deposition of the glaciofluvial sediments occurring here.

The gradual transitions between varved clay and beach deposits with laminae of clay at site 131 (Chapter 7.3.1), site 136 (Chapter 7.3.4) and site 140 (Chapter 7.3.5) suggest that a regression prevailed when the plain around Kristianstad was deglaciated.

8.1 Morphology, bedrock, glacial striae and till

The valley landscape north of Kristianstad reaches 150–175 m a.s.l. in the north, 15–65 m a.s.l. in the southwest and 15–175 m a.s.l. in the southeast (Plate 1). The valleys and depressions trend mainly between the north-northwest – south-southeast and the north-northeast – south-southwest, which is reflected in the fluvial drainage pattern of the area (Fig. 90). The valleys and the depressions are less than 20 m deep in the area north of Immeln Lake. In the northernmost part of this area, they are often less than 10 m deep. In the area west of Immeln Lake, the valleys and depressions are 20–30 m deep and east of this lake, 20–100 m deep. The morphology of the valley landscape is illustrated in

Figs. 92–99 and described in further detail in Chapter 8.2.

The bedrock is predominantly gneiss, gneissic granite and granite (Fig. 57). Sedimentary kaolin and kaolinization of the igneous bedrock occur in the southern part of the valley landscape (Bergström & Shaikh 1980). A 25 km long and up to 2 km wide zone with mica quartzite extends from a point located 2.5 km south-southeast of Näsrum in a northwesterly direction to Immeln Lake (Plate 1, Fig. 57). Cretaceous limy sandstone, sandy limestone and limestone are found in depressions in the southern part of the valley landscape (Bergström & Shaikh 1980). The largest outcrop of these kinds of rocks is located in the area southwest of Hjärsås. The bedrock is sparsely exposed except in the area southeast and east of Immeln Lake.

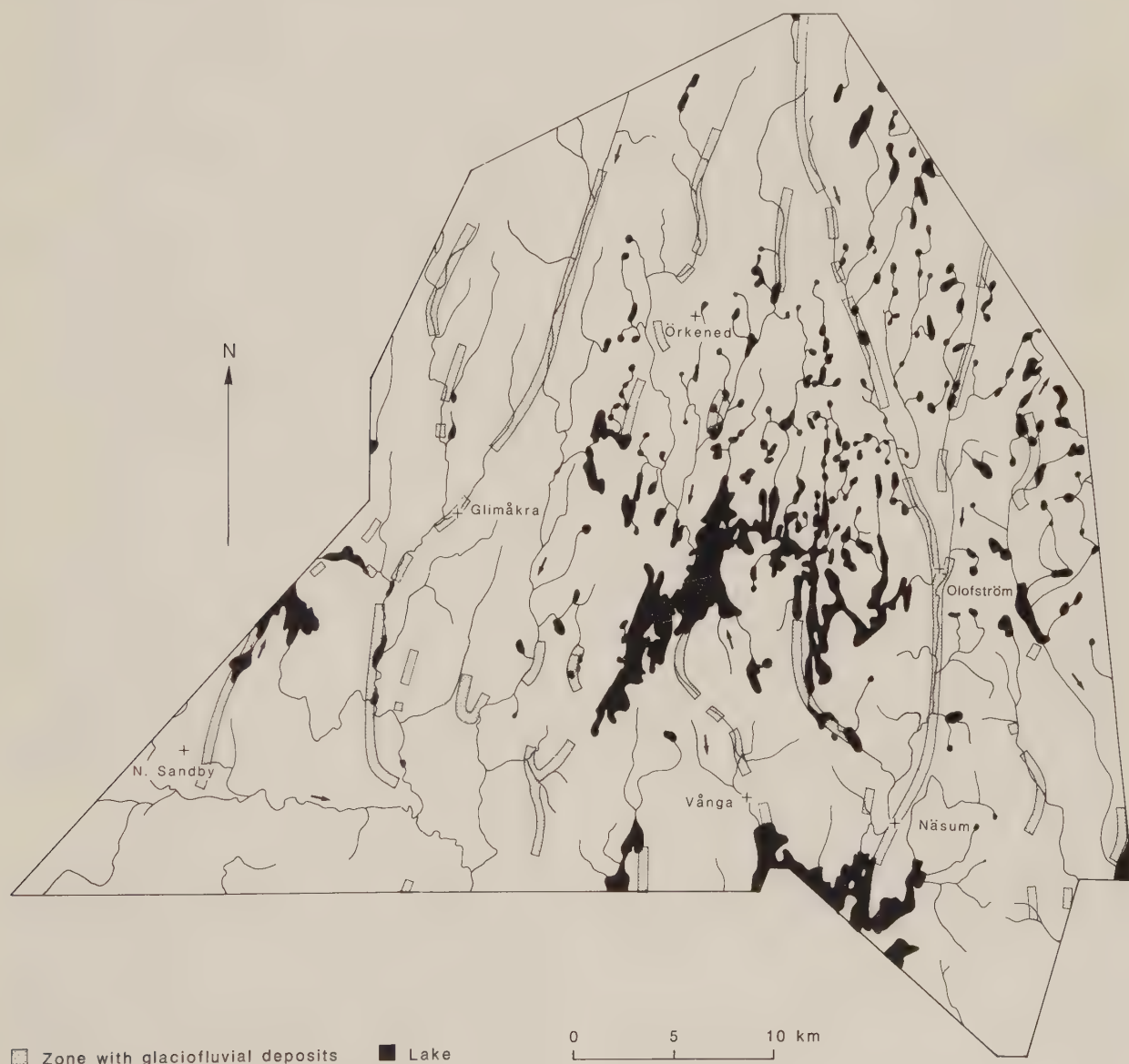
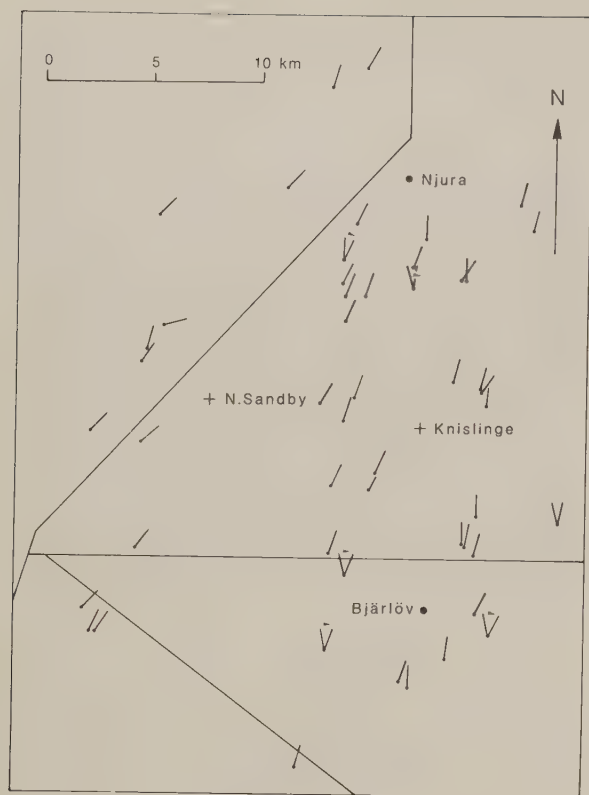


Fig. 90. The fluvial drainage pattern and the zones with glaciofluvial deposits in the valley landscape north of Kristianstad.



△ Glacial striae. Older and younger direction

Fig. 91. Glacial striae in the southwestern part of the valley landscape and in the surrounding areas.

The glacial striae indicate mainly an ice movement from between the north and the north-east in the western part of the valley landscape and from the north in the eastern part. In the southwestern part of the landscape and in the surroundings, the glacial striae form a diverging pattern (Fig. 91). At Tydingen Lake and at Ö. Broby, striae suggesting an older ice movement from between the north and the north-northwest occur (G. De Geer 1889b). Striae indicating an ice movement from the east have been observed at a site situated 4 km east-northeast of Näsum. The site is located on the steep, northern slope of an east-west trending depression.

Well bore logs and observations made by Lindström (1877), G. De Geer (1889b) and Blomberg (1892) show that the till in the low-lying parts of the landscape is about 5 m thick. The thickness usually varies between 2 m and 10 m, but up to 20 m thick till beds have been observed. The till forms mainly a cover reflecting the irregularities of the underlying bedrock surface. Hummocks of till that are 50–100 m in diameter and up to about 5 m high are found in areas located above 50–60 m a.s.l. Mostly east-west trending ridges of till occur in a zone between Blistorp and the southern end of Immeln Lake (G. De Geer 1889b). Some ridges are also located west of the southern end of Immeln Lake. The westernmost ridge is situated 3 km east-northeast of Hjäsås and trends northwest-southeast. The ridges are 100–250 m long, 20–40 m wide and 3–6 m high. The sides of the

ridges dip 11–26°.

The till is mainly sandy, but clayey till and clay till are found where sedimentary kaolin or kaolinized bedrock occurs. The boulder and stone content of the till is moderate to high and fragments of gneiss, gneissic granite and granite predominate. South of the zone with mica quartzite, boulders of this kind of rock occur east of a line crossing Oppmanna and orientated at 5–185° (G. De Geer 1889b). Boulders of mica quartzite have been observed as far south as immediately south of Ivösjön Lake.

8.2 Glaciofluvial deposits

The glaciofluvial deposits form zones that trend between the north-northwest – south-southeast and the northeast-southwest (Plate 1). The deposits are located in valleys and depressions (Fig. 90). Below 50–60 m a.s.l., they form mounds, plateaus and ridges. Sand and gravelly sand make up the mounds and plateaus and the ridges are composed of stony gravelly sand. The plateaus in the valley at Vånga and in the Näsum – Olofström valley are delta deposits, the surfaces of which reach 50–60 m a.s.l. Above 50–60 m a.s.l., stony gravelly sand mainly forming ridges, mounds and hummocks constitutes the glaciofluvial deposits.

The glaciofluvial deposits and their location in the landscape are described at length in Chapters 8.2.1–8.2.19.

The deposits north of a point located 4 km north of Duvhult (Plate 1), north of Tosthult, between a point located 3 km south of Rumpeboda and Långhult as well as the deposits around Farabol have been mapped by P. Möller of the Department of Quaternary Geology, University of Lund, who kindly placed his maps at my disposal. The rest of the deposits are according to Lindström (1877), G. De Geer (1889b), Blomberg (1892, 1900) and Rydenheim (1973). My investigations comprise air photo interpretation and, in parts of the valley landscape, mapping, field controls and investigation of exposures.

8.2.1 The N. Sandby – Njura deposits

The N. Sandby – Njura deposits (Rydenheim 1973: the Tydinge esker and the deposits east of river Helgeå) are located in an area with valleys and depressions trending between the north-northeast – south-southwest and the northeast-southwest (Plate 1). The stratified drift between N. Sandby and Tydingen Lake is located in a less than 15 m deep depression (Fig. 92A). The floor of the depression reaches 70–75 m a.s.l. 2 km south of Kallsjön Lake. It slopes northward north of and southward south of this point.

A zone with stratified drift occurs in Tydingen Lake west of the investigated area. The glaciofluvial deposit 1 km northeast of the northern end of Tydingen Lake is located in a 300 m wide and 5 m deep depression, the floor of which slopes toward the north. The deposits at Njura are situated at the mouth of a north-northeast – south-southwest trending valley. The valley floor slopes toward the south. At Njura the valley is about 700 m wide and 5–10 m deep. It narrows and deepens toward the north.

Mounds and up to 10 m high ridges of stony gravelly sand make up the glaciofluvial deposits (Rydenheim 1973).

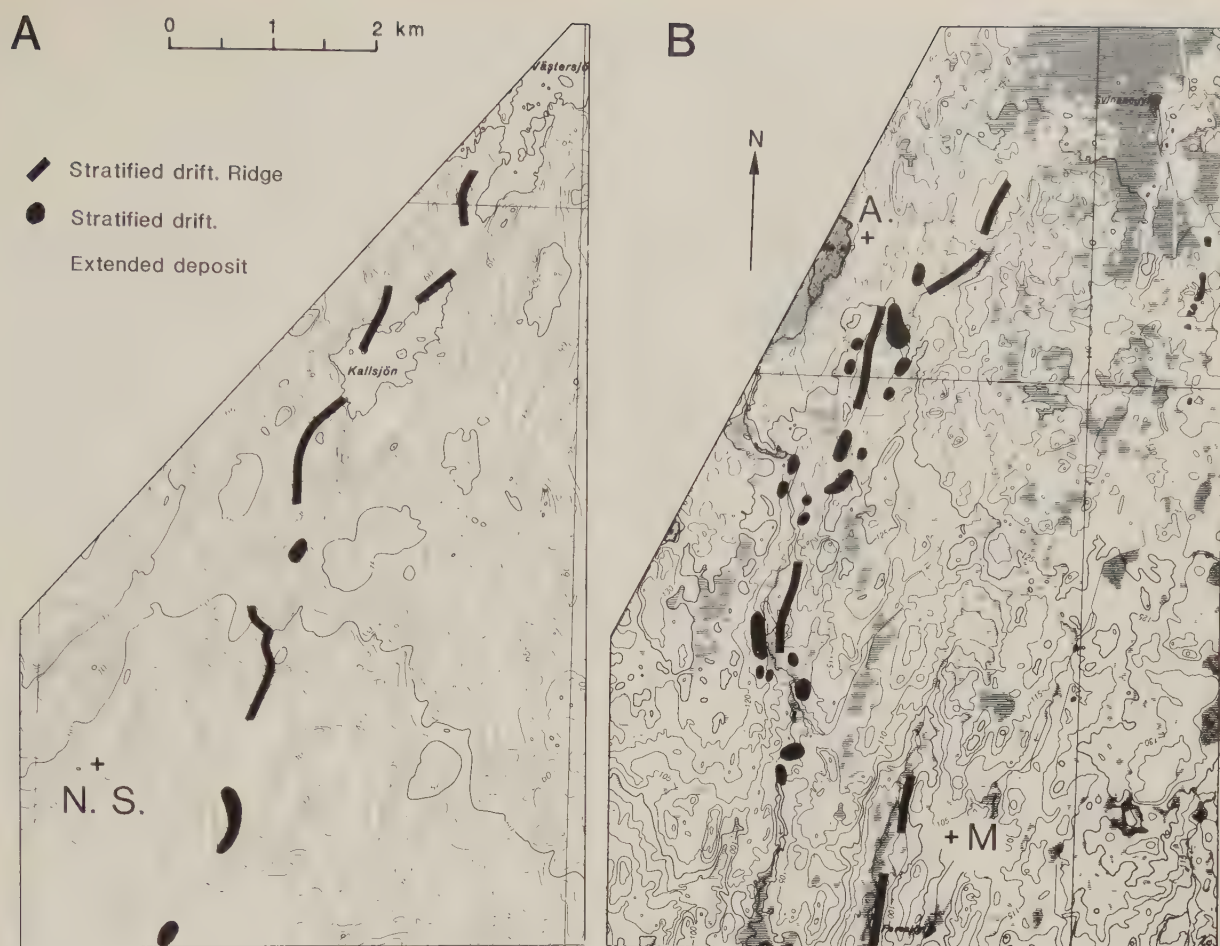


Fig. 92. Glaciofluvial deposits. A. The southern part of the N. Sandby - Njura deposits. N. S. = N. Sandby. B. The Abrölla deposits and the northern part of the zone with glaciofluvial deposits at Mölleröd. A. = Abrölla. M. = Mölleröd.

8.2.2 The Abrölla deposits

The Abrölla deposits (Rydenheim 1773: the Abrölla esker) form a north-northeast - south-southwest trending zone (Fig. 92B). The deposits are located in an about 700 m wide and mainly less than 10 m deep depression with a southward sloping floor. The northern part of the zone with stratified drift is surrounded by irregular and closed depressions. The relative relief here is 5-10 m.

Ridges, mounds and hummocks of stony gravelly sand make up the deposits (Blomberg 1892; Rydenheim 1973).

8.2.3 The Mölleröd deposits

The Mölleröd deposits (Rydenheim 1973: the Mölleröd esker) are located in a valley trending roughly north-northeast - south-southwest. The northern part of the valley is shown in Fig. 92B and the southern part in Fig. 94A. The valley is 200-500 m wide, 15-25 m deep and its floor slopes toward the south. Toward the north, the valley shallows and ultimately disappears 1.5 km north of the northernmost glaciofluvial deposit (Fig. 92B).

Ridges and hummocks of stony gravelly sand make up the glaciofluvial deposits (Blomberg 1892; Rydenheim 1973).

8.2.4 The Bjärlöv - Ö. Broby deposits

Bjärlöv - Ö. Broby deposits (Rydenheim 1973: The Helga esker) form two roughly north-south trending zones. North of Bjärlöv, the glaciofluvial deposits are situated in a 500 m wide and 5-10 m deep depression, trending north-northeast - south-southwest. North of a point located 2.5 km north of Bjärlöv, the floor of the depression slopes toward the north. Between Knislinge and Ö. Broby, the deposits constituting the western zone are situated in a north-south trending depression that is up to 1 km wide and less than 15 m deep (Fig. 93). The floor of the depression slopes toward the north immediately north of Knislinge. The southern part of the eastern zone is located in a 0.7-1.5 km wide and about 10 m deep depression. The northern part of the zone is found on the eastern side of a depression.

The glaciofluvial deposits form mounds of gravelly sand and sand and a ridge of stony gravelly sand (G. De Geer 1889b; Rydenheim 1973).

8.2.5 The Glimåkra - Kärraboda deposits

The Glimåkra - Kärraboda deposits (Rydenheim 1973: The Kärraboda esker) form a roughly north-northeast - south-southwest trending

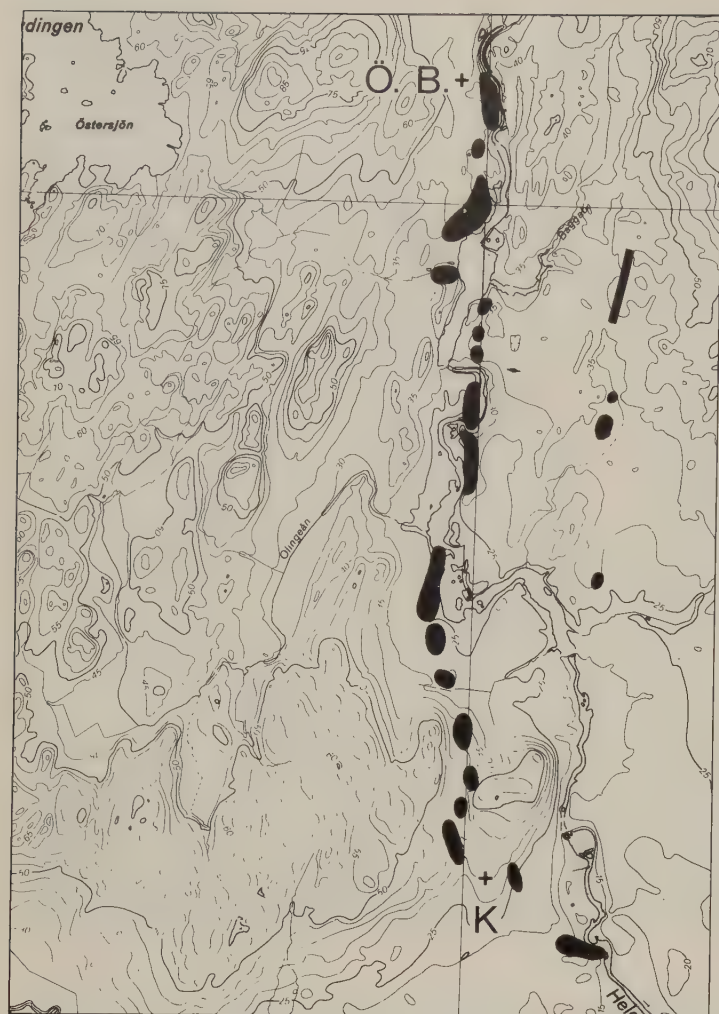


Fig. 93. The glaciofluvial deposits between Knislinge and Ö. Broby. K. = Knislinge. Ö.B. = Ö. Broby.

zone. At and southwest of Glimåkra, the deposits are situated in a 300–700 m wide and up to 20 m deep valley (Fig. 94A). The valley continues from Glimåkra toward the north-northeast, shallows in this direction and disappears 1 km south of Bösakulla (Fig. 94B). Between Bösakulla and Kärraboda, the deposits are situated in a north-northeast – south-southwest trending valley that is 500–700 m wide and 15–20 m deep (Fig. 94B). The valley floor slopes toward the south.

Ridges, mounds, hummocks and thin covers of stony gravelly sand make up the deposits (Blomberg 1892; Rydenheim 1973).

8.2.6 The Hjäsås deposits

The Hjäsås deposits (Rydenheim 1973: the Hjäsås deposits) are composed of three zones with stratified drift. The western zone is located at the eastern side of a depression that is about 1 km wide and 10 m deep. The eastern zone is situated in an about 200 m wide and 10 m deep depression. The depressions trend roughly north-south and their floors slope toward the south. The southern zone is located in a west-northwest – south-southeast trending depression that is 300 m wide and 5–10 m deep. From the central part of the depression, the floor slopes toward the west-northwest and the east-southeast.

Ridges and hummocks of stony gravelly sand constitute the glaciofluvial deposits (G.

De Geer 1889b). According to De Geer, the ridge in the western zone is 8–14 m wide and 1.5–2.0 m high.

8.2.7 The Sibbhult deposits

The Sibbhult deposits (Rydenheim 1973: the Råbelöv esker, the Hylta area) form mainly two zones with stratified drift (Fig. 95A). The western zone is located in the valley in which the Sibbhultaån Stream runs. The valley floor slopes toward the south and south of Sibbhult, the valley is 0.5–1 km wide and about 20 m deep. The western zone is situated in a roughly north-south trending depression that is 300–500 m wide. The northern part is up to 25 m deep. The floor of the depression slopes strongly toward the north, south-southwest of Ramsjön Lake and gently toward the north, north of this lake.

Ridges, mounds and hummocks of stony gravelly sand make up the glaciofluvial deposits (G. De Geer 1889b).

8.2.8 The Örkened deposits

South-southwest of Örkened, two zones with glaciofluvial deposits occur (Fig. 95B). The southern zone (Rydenheim 1973: the Gårdsjö deposits) is located in a 200–500 m wide, less than 10 m deep and north-northeast – south-southwest trending depression. The floor

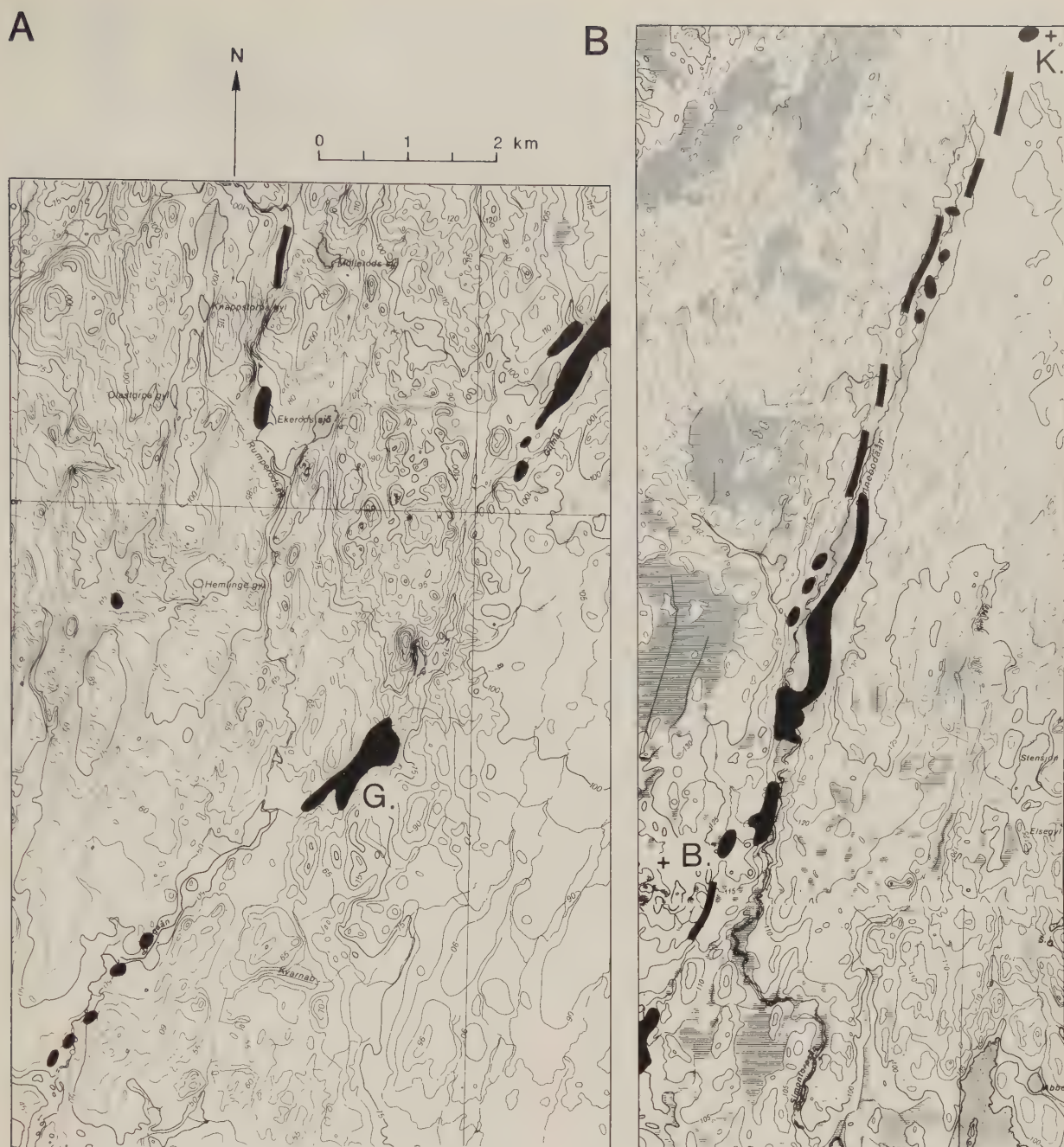


Fig. 94. Glaciofluvial deposits. A. The southern parts of the Mölleröd and Glimåkra - Kärraboda deposits. G. = Glimåkra. B. The northern part of the Glimåkra - Kärraboda deposits. B. = Bösakulla. K. = Kärraboda.

of the depression slopes toward the south-southwest except at the northernmost deposit where it slopes in the opposite direction. Irregular heights and closed depression occur in the surroundings of the zone with stratified drift. The northern zone is found in the valley into which the Tommabodaän Stream drains. The part of the valley in which the stratified drift is located is 200-500 m wide, 15 m deep and trends north-northwest - south-southeast. The valley shallows toward the north and disappears 2.5 km north of the northernmost deposit of stratified drift.

Ridges, mounds and hummocks of stony gravelly sand make up the glaciofluvial deposits (Blomberg 1892; Rydenheim 1973).

8.2.9 The Duvhult deposits

The northern and central parts of the zone with stratified drift north of Duvhult (Rydenheim 1973; the Duvhult esker) are situated in a roughly north-northeast - south-southwest trending depression (Fig. 95C). The depression is 0.5-1.0 km wide, less than 10 m deep, and its floor slopes toward the south. It shallows toward the north and disappears about 9 km north-northeast of Duvhult. From 11 km north-northeast of Duvhult and northward, brooks are drained toward the north. The relative relief in the area surrounding the depression is less than 10 m. The stratified drift in the southern part of the zone

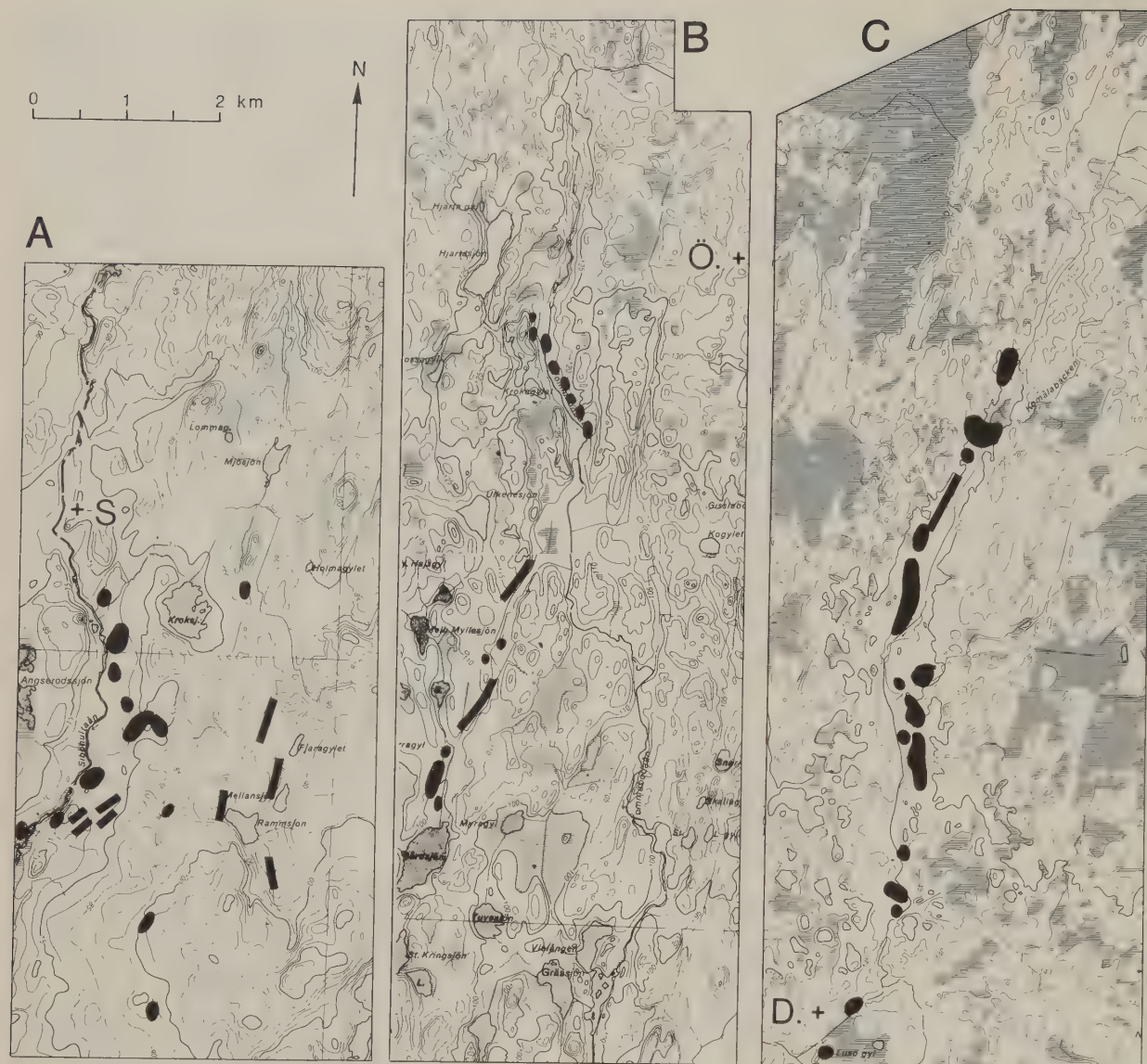


Fig. 95. Glaciofluvial deposits. A. The Sibbhult deposits. S = Sibbhult. B. The Örkened deposits. Ö = Örkened. C. The Duvhult deposits. D. = Duvhult.

is located between less than 10 m high heights. The heights are irregular and the intervening depressions are closed.

Mounds, hummocks and thin covers of stony gravelly sand make up the glaciofluvial deposits (Blomberg 1982; Rydenheim 1973; P. Möller pers. comm.).

8.2.10 The Brännskulla deposits

The Brännskulla deposits (Rydenheim 1973: the Råbelöv esker, the Hylta area) form one roughly north-south trending and one north-east-southwest trending zone (Fig. 96A). The northern part of the north-south trending zone is located in a less than 5 m deep depression. The central and southern parts are situated between up to 25 m high heights in a depression between two high-lying areas (Plate 1). The northeast-southwest trending zone is located in an about 5 m deep depression. The floor of the depression slopes toward the southwest except at the southern end of Immeln Lake (2.6 km north-northeast of Brännskulla), where it slopes toward the east. Immeln Lake

here is 9 m deep (Persson 1932).

Ridges, mounds and hummocks of stony gravelly sand constitute the glaciofluvial deposits (G. De Geer 1889b; Rydenheim 1973).

8.2.11 The Oppmanna deposits

At Oppmanna, the Oppmanna deposits (Rydenheim 1973: the Oppmanna esker) are located in a 800 m wide and about 20 m deep depression. The floor of the depression reaches 25-30 m a.s.l. 400 m northwest of Oppmanna and slopes from here toward the north and the south. The valley in which Oppmannasjön Lake is situated continues to Immeln Lake (Plate 1, Fig. 96B). Two small deposits of stratified drift occur in the valley north of Oppmannasjön Lake. The northern deposit is located 2 km west-southwest of Lerjesjön Lake (Fig. 96B).

8.2.12 The Vånga deposits

Around Vånga, the Vånga deposits (Rydenheim 1973: the Vånga esker) are located in a



Fig. 96. Glaciofluvial deposits. A. The Brännskulla deposits. B. = Brännskulla. B. The northern part of the Vånga deposits. V. = Vånga.

north-northwest - south-southeast trending valley that is about 2 km wide and 100 m deep. The valley divides into several smaller valleys 2 km north of Vånga (Fig. 96B). The valley in which the stratified drift is located trends between the northeast-southwest and the north-south. It is 0.5-1.2 km wide and about 50 m deep. The valley floor reaches 100-105 m a.s.l. 2.2 km northeast of Lerjesjön Lake. From here it slopes toward the northwest and the southeast. North of the northern mouth of the valley, the stratified drift is situated in a shallow depression that slopes gently toward the north. The glaciofluvial deposits at Immeln Lake are located 80-85 m a.s.l.

The body of gravelly sand 1.5 km north of Vånga is a delta, the top surface of which reaches 50-57 m a.s.l. (Hellberg 1971). Some of the stratified drift making up the delta was deposited in contact with stagnant glacier ice and has later been dissected by brooks. The ridges between the delta and Immeln Lake are up to 60 m wide and as much as 15 m high (G. De Geer 1889b). They and the mounds of stratified drift are made up of stony gravelly sand (G. De Geer 1889b; Rydenheim 1973). The bedrock is exposed in the gap between the ridges 2.2 km northeast of Lerjesjön Lake (G. De Geer 1889b).

8.2.13 The S. Rågeboda deposits

The S. Rågeboda deposits (Rydenheim 1973: the Rågeboda deposits) form a north-northeast

- south-southwest trending zone (Fig. 97A). The stratified drift is located between less than 15 m high heights. The ground surface along with the zone with stratified drift is undulating. Fåknasjön Lake and Gylsboda Lake drain by southeastward-flowing brooks into the Felån Stream. The deposits are located south of a branch of the valley in which Felån Stream runs.

Ridges and hummocks of stony gravelly sand make up the glaciofluvial deposits (Blomberg 1892; Rydenheim 1973).

8.2.14 The Tosthult deposits

The Tosthult deposits (Rydenheim 1973: the Tosthult esker) are situated in a roughly north-south trending depression that is about 500-800 m wide and 5-15 m deep. The floor of the depression slopes toward the south. The depression shallows toward the north; its northern part is shown in Fig. 98B. The relative relief in the surrounding areas is less than 10 m.

Mounds, hummocks and thin covers of stony gravelly sand make up the deposits (Blomberg 1892; Rydenheim 1973; P. Möller pers. comm.).

8.2.15 The Blistorp deposits

The Blistorp deposits (Rydenheim 1973: the Blistorpa deposits) form a northwest-southeast to north-south trending zone (Fig. 97B). The

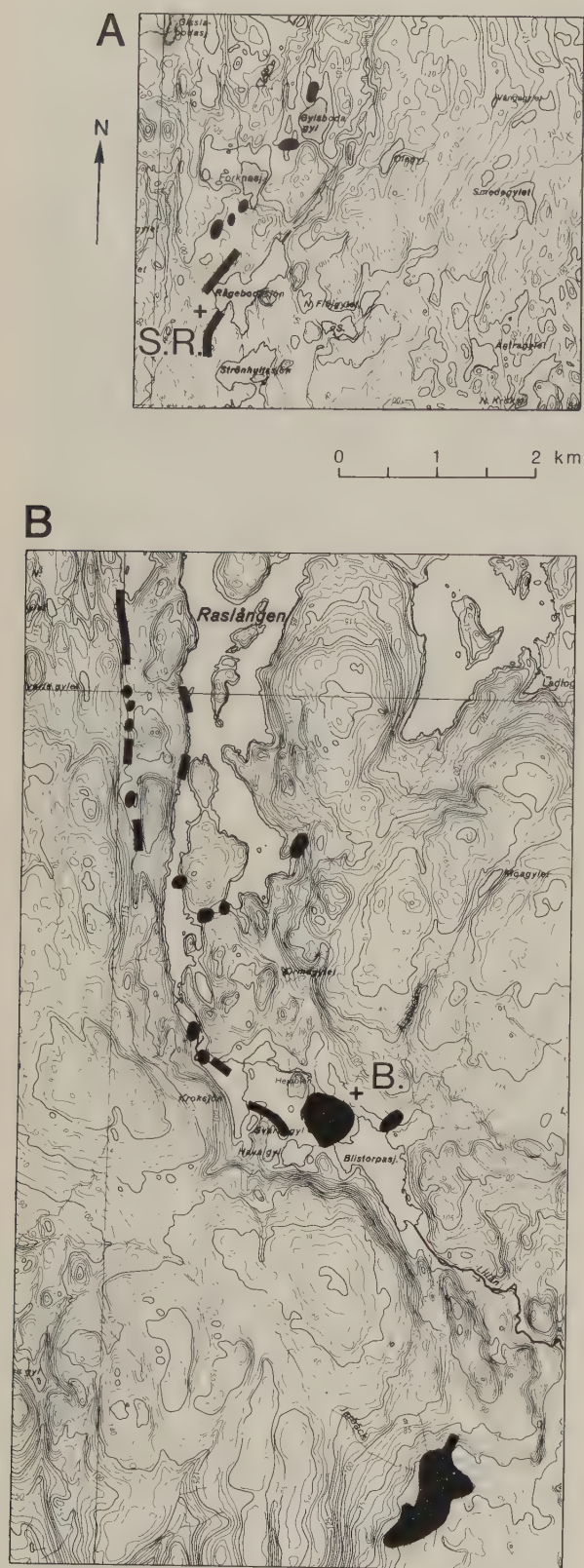


Fig. 97. Glaciofluvial deposits. A. The S Rågeboda deposits. S. R. = S. Rågeboda. B. The Blistorp deposits. B. = Blistorp.

deposits south of Blistorpasjön Lake are located at the mouth of a north-northwest - south-southeast trending valley. The valley

floor reaches 95-100 m a.s.l. 2.5 km south-southeast of Blistorp and slopes from here toward the north-northwest and the south-southeast. At Råslängen Lake and between this lake and Blistorpasjön Lake, the stratified drift is situated between less than 25 m high heights in an about 2 km wide and 75 m deep valley. The deposits east of Lake Råslängen occur in a 200-400 m wide depression between 25-50 m high heights. The floor of the depression at the southernmost deposit reaches 100 m a.s.l., and 75 m a.s.l. at the northernmost deposit.

The extended deposits southwest of Blistorp and south of Blistorpasjön Lake consist of stony gravelly sand (G. De Geer 1889b) and have gently undulating surfaces. Ridges, mounds and hummocks of stony gravelly sand make up the rest of the glaciofluvial deposits (G. De Geer 1889b; Rydenheim 1973).

8.2.16 The Näsrum - Olofström deposits

The Näsrum - Olofström deposits are located in a north-south to north-northeast - south-southwest trending valley. The valley is about 1.5-4.0 km wide except in the area 1-5 km south of Olofström where it is only 250-700 m wide. The southern part of the valley is about 100 m deep and the northern part is 25 m deep. The valley floor slopes toward the south.

Mainly mounds and plateaus of gravelly sand surrounded by sand with a horizontal surface constitute the glaciofluvial deposits in the southern and central parts of the valley (G. De Geer 1889b; Hellberg 1971; Rydenheim 1973). Some ridges of stony gravelly sand also occur. The mounds and plateaus are marginal delta deposits (Hellberg 1971; Rydenheim 1973; Åmark 1979). The top surfaces of the plateaus reach 55-57 m a.s.l. (Hellberg 1971). Between 1 and 5 km south of Olofström, stony gravelly sand and gravelly sand fill the lower part of the valley. The gravelly sand at Olofström is a delta deposit the surface of which reaches 56-59 m a.s.l. (Hellberg 1971).

8.2.17 The Olofström - Långhult deposits

The Olofström - Långhult deposits form a north-northwest - south-southeast trending zone. Between Olofström and Rumpeboda, the deposits are located in a valley with a southward sloping floor. The valley between Olofström and a point located 3 km north-northwest of Vilshult is 200-600 m wide, about 20 m deep and trends north-northwest - south-southeast (Fig. 98A). Between this point and Rumpeboda, the valley trends north-northwest - south-southeast to north-south and is 0.25-1.0 km wide. It is mainly 20 m deep but shallows and disappears at Rumpeboda (Fig. 98B). The stratified drift between Rumpeboda and Långhult is located in an area with irregular heights and depressions (Fig. 98B). The relative relief is less than 10 m. The southern part of the zone with stratified drift is situated between heights and the central part on heights. The northern part of the zone is located on the eastern side of a shallow depression. Immediately north of the investigated area, the deposits continue toward the north and are located in a depression that is occupied by Femlingen Lake. North of a north-west-southeast trending line crossing the southern end of Hagasjön Lake, brooks are drained toward the north, and south of this line, toward the south.



Fig. 98. Glaciofluvial deposits. A. The southern parts of the Olofström - Långhult deposits and the Olofström - Farabol deposits. O. = Olofström. V. = Vilshult. B. The northern parts of the Tosthult and the Olofström - Långhult deposits. R. = Rumpeboda. L. = Långhult.

Stony gravelly sand filling the lower part of the valley makes up the glaciofluvial deposits between Olofström and a point located 5 km north-northwest of Vilshult (Blomberg 1892, 1900). Between this point and Långhult, ridges, mounds, hummocks and thin covers of stony gravelly sand predominate (Blomberg 1892; P. Möller pers. comm.).

8.2.18 The Olofström - Farabol deposits

The Olofström - Farabol deposits are located in a north-northeast - south-southwest trending valley that is 200-500 m wide and about 25 m deep. The valley floor slopes toward the south. The southern part of the valley is shown in Fig. 98A. The two southern deposits in Fig. 98A are situated in a depression west of the main valley. The floor of the depression slopes toward the north, north of the southernmost deposit. The valleys and depressions surrounding the Olofström - Farabol valley trend mainly north-northeast - south-south-

west.

Stony gravelly sand filling the lower part of the valley makes up the glaciofluvial deposits (Blomberg 1900; P. Möller pers. comm.).

8.2.19 The Ebbalycke - Tulseboda deposits

The deposits between Ebbalycke and Orlunden Lake are located in north-south trending depressions that are 0.3-1.0 km wide and about 25 m deep. The floors of the depressions slope mainly toward the south. The deposits south of Tulseboda are situated between less than 15 m high heights (Fig. 99). The ground surface along the zone with stratified drift is undulating. The lakes surrounding the deposits are drained toward the north or the east.

Stony gravelly sand constitutes the glaciofluvial deposits. It forms ridges, mounds, hummocks and an extended deposit located 6 km south of Ebbalycke (Blomberg 1900).

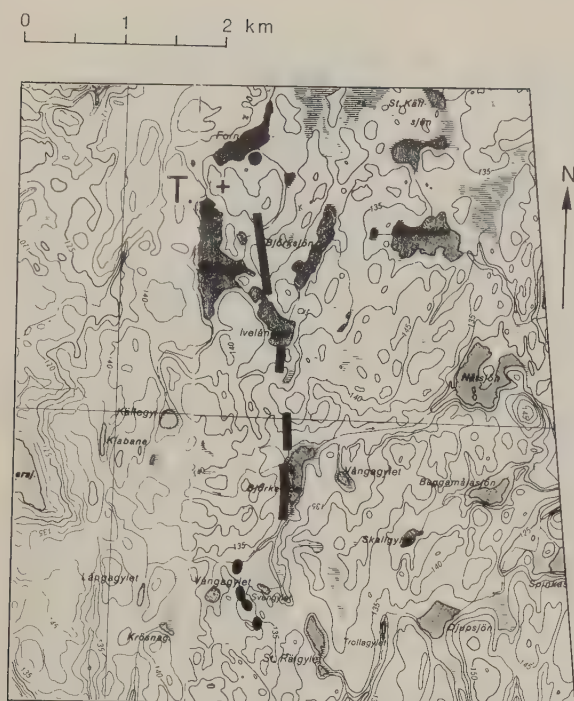


Fig. 99. The Tulseboda deposits. T. = Tulseboda.

8.3 Varved clay

Varved clay is common below 25 m a.s.l., but has been observed above this level up to 41.9 m a.s.l. (G. De Geer 1889b). The largest exposures are found in the area around Knislinge and west of Näsrum (Plate 1). Well bore logs and observations by Lindström (1877) show that the sand in the areas south of N. Sandby and Hjärsås is often underlain by varved clay. Also in parts of the valley at Vånga and in the Näsrum - Olofström valley, varved clay occurs beneath sand. The clay is usually some meters thick (Lindström 1877; G. De Geer 1889b) and it resembles the varved clay in the northern part of the plain around Kristianstad (Chapter 7.4).

At two sites located 7 km south of Olofström, Ringberg (1971) observed that the deposition of the medium-sandy silt making up the summer layers in three proximal varves lasted 43, 44 and 49 days respectively. Thin beds and laminae of medium-sandy fine and coarse silt alternating with thin beds and laminae of medium and fine silt constitute the summer layers, which are 37, 66 and 75 cm thick. The winter layers consist of clay.

Antevs' (1915) and Ringberg's (1979) varve chronological investigations showed that the ice sheet receded toward the north and that the ice margin trended roughly east-west in the southern part of the valley landscape. Ringberg's recession lines are shown in Fig. 100.

8.4 Beach deposits

Beach deposits are common in the southern part of the valley landscape up to 50-60 m a.s.l. (G. De Geer 1889b; Blomberg 1900; Hellberg 1971; Dahlberg 1976; Malmberg 1976; L. Nilsson 1976; Svensson 1976). Munthe (1940) and E. Nilsson (1942, 1953, 1968) have ob-

served beach deposits and bench marks up to 108 m a.s.l. Only the largest beach deposits of stony gravelly sand are indicated in Plate 1.

The geological mapping by G. De Geer (1889b) showed that beach deposits of stony gravelly sand occur northwest of Knislinge and north of Hjärsås. The deposits reach up to about 55 m a.s.l. according to the Topographical Map. Since the sand occurring around and south of N. Sandby and Hjärsås is often underlain by varved clay, it ought to form beach deposits or delta deposits. It is found up to about 55 m a.s.l. around N. Sandby and north of Hjärsås.

According to Munthe (1940) and E. Nilsson (1942, 1953, 1968), beach deposits and bench marks occur between 72.0 and 102.0 m a.s.l. in the area between Oppmanna and Immeln Lake. I have, however, not found any beach deposits or bench marks in this area.

On the southern side of the hill between Vånga and Näsrum, beach deposits of stony gravelly sand are found up to 52.5-58 m a.s.l. (G. De Geer 1889b; Hellberg 1971). The deposits are as much as 400x75 m large.

E. Nilsson (1942, 1953, 1968) stated that beach deposits and bench marks occur between 55.0 and 121 m a.s.l. at and northeast of Olofström.

Large beach deposits occur on the hill of Ryssberget. Only the largest of these deposits are shown in Plate 1. The deposits reach up to 52-58 m a.s.l. according to Blomberg (1900), Hellberg (1971), Dahlberg (1976), Malmberg (1976), L. Nilsson (1976) and Svensson (1976). They are made up of stones, gravel and sand forming up to more than 1 km long and 70-150 m wide continuous deposits (Malmberg 1976). Hellberg (1971) mapped 17 beach ridges between 29.7 and 56.0 m a.s.l. on the southern end of Ryssberget. Bench marks occur some meters above the beach deposits (Hellberg 1971). Dahlberg (1976), Malmberg (1976), L. Nilsson (1976) and Svensson (1976) showed by soil sampling along in all eight lines trending perpendicular to the contour lines that the till was not influenced by wave-washing above 52-57.2 m a.s.l. The limit between washed and unwashed till is located 0.5-2 m above the beach deposits. Munthe (1940) and E. Nilsson (1953, 1968) observed beach deposits and bench marks up to 101.0 m a.s.l. at some sites on Ryssberget. These observations were not accepted by Hellberg (1971), Dahlberg (1976), Malmberg (1976), L. Nilsson (1976) and Svensson (1976).

8.5 The deglaciation of the valley landscape north of Kristianstad

8.5.1 The properties and the recession of the ice sheet

The sediments making up the glaciofluvial deposits in the valley landscape north of Kristianstad were transported by meltwater flowing along the base of an ice sheet with a sloping surface, since the deposits are often located in valleys and depressions which mainly are less than 25 m deep and since the meltwater drainage was controlled not only by the morphology of the landscape. The latter is indicated by three facts. Firstly, the meltwater which transported and deposited the glaciofluvial sediments often flowed in an up-slope direction. Secondly, the locations of the zones with glaciofluvial deposits at S.

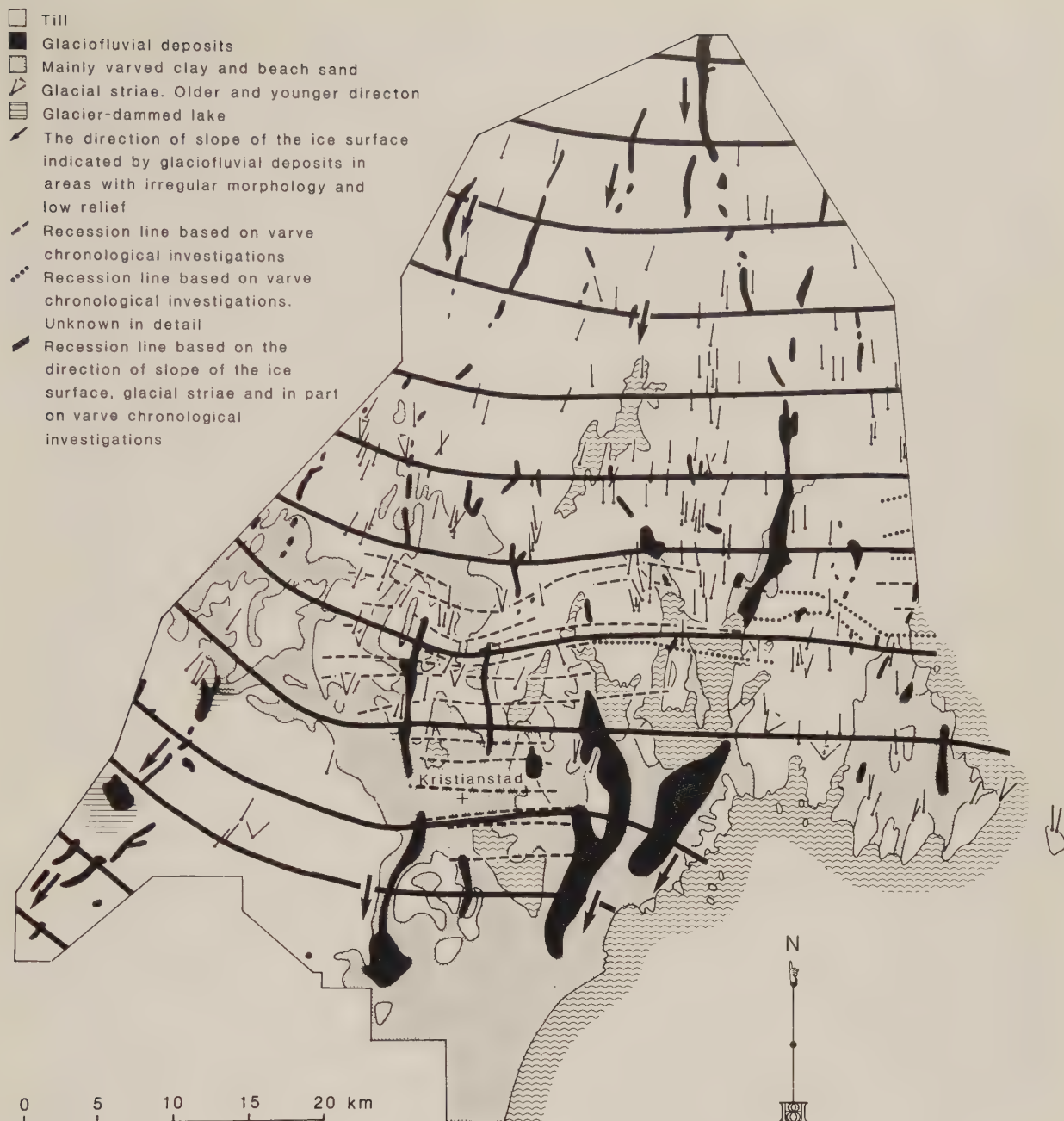


Fig. 100. The recession of the ice sheet on the Nävlingeåsen horst, in the Häglinge area, on the plain around Kristianstad and in the valley landscape north of Kristianstad. The recession lines based on varve chronological investigations are according to Ringberg (1979).

Rågeboda and Tulseboda are not related to the fluvial drainage pattern (Figs. 97A and 99). Thirdly, only the northern part of the zone with glaciofluvial deposits between Glimåkra and Kärraboda is situated along Simonstorpsån Stream (Fig. 94B). Where the stream turns to the east at Bösakulla, the deposits continue toward the southwest in another valley. Similar circumstances are valid for the Örkened deposits (Fig. 95B). These three facts indicate that the meltwater flowed beneath an ice sheet with a sloping surface. They exclude the possibility that the glaciofluvial sediments were transported by surface meltwater which flowed on the surface of a non-disintegrated part of the ice sheet and in connection with stagnant ice, occurring in front of the non-

disintegrated part of the ice sheet, became concentrated to the valleys and depressions and deposited the sediments there.

The stony gravelly sand which occurs above 50–60 m a.s.l. and forms mounds and hummocks accumulated in connection with stagnant disintegrating glacier ice (see below). However, it was transported by meltwater flowing in a part of the ice sheet that had a sloping surface and was non-disintegrated. The sloping surface shows that this part of the ice sheet was active. Thus, stagnant ice existed in front of the active ice in areas above 50–60 m a.s.l. Since the meltwater drainage was controlled by the active part of the ice sheet, the stony gravelly sand was transported only a short distance in the stag-

nant ice before deposition. Therefore, the ice sheet receded by gradual stages above 50-60 m a.s.l. This is also shown by the occurrence of alternating ridges, mounds and hummocks along the zones with glaciofluvial deposits. The ridges were formed in connection with stagnant but non-disintegrated glacier ice, and the mounds and the hummocks, in connection with stagnant and disintegrating glacier ice (cf. Chapter 5.6.4). Since it is unlikely that in a north-south direction, zones with alternating disintegrating and non-disintegrated glacier ice occurred, the deposition of the stratified drift cannot have taken place simultaneously in the central and northern parts of the valley landscape. But the occurrence of alternating ridges, mounds and hummocks can be explained if the ice sheet became stagnant by gradual stages in a northerly direction and little by little disintegrated.

The varve chronological investigations (Ringberg 1979) show that the ice sheet receded by gradual stages toward the north in the southern part of the valley landscape (Fig. 100). This is also indicated by the marginal delta deposits in the valley between Näsrum and Olofström.

Also the glacial striae around and south of Njura (Fig. 91) indicate that the ice sheet was active when it receded. If these striae were formed simultaneously, this would show that the ice flow diverged from a point located north of Njura. Since the flow of a glacier cannot diverge from a point, it is more likely that the striae reflect the last ice movement at the margin of a gradually northward-receding and active ice sheet.

G. De Geer (1889b) considered that the till ridges west of and between the southern end of Immeln Lake and Blistorp are 'terminal moraines'. De Geer's description of the ridges may indicate that the ridges are some kind of marginal features formed by an active ice sheet.

The irregular morphology and the low relief in the area around Abrölla (Fig. 92B), in the area where the north-northeast - south-southwest trending zone with stratified drift south-southwest of Örkened occur (Fig. 95B), around Duvhult (Fig. 95C), and south of Långhult (Fig. 98B) cannot have controlled the main flow direction of the subglacial meltwater. Consequently, the trends of the zones with stratified drift occurring here indicate the direction of slope of the ice surface: during the recession of the ice sheet (Fig. 100).

Not only the glacial striae around and south of Njura (Fig. 91) but also the majority of the glacial striae in the rest of the valley landscape ought to indicate ice movement directions prevailing near the margin of the ice sheet, since the ice sheet was active during the recession except for a marginal zone with stagnant ice occurring in parts of the valley landscape.

The recession lines in Fig. 100 are based

on glacial striae, on the direction of slope of the ice surface indicated by glaciofluvial deposits in areas with irregular morphology and low relief and on Ringberg's 1979 recession lines. They indicate the trend of the ice margin where in the southern part of the valley landscape, the ice sheet terminated in standing water (Chapter 8.5.2) and the boundary between stagnant and active glacier ice in the rest of the landscape.

The general trend of the zones with glaciofluvial deposits is parallel to the ice movement direction indicated by the glacial striae. However, the individual zones often form an angle with the striae. This is due to the fact that the subglacial meltwater which transported and deposited the glaciofluvial sediments flowed mainly along the widest, deepest and longest valleys in the area (Figs. 92-99). Preferably, the meltwater was also drained along valleys and depressions with southward-sloping floors. Since the trend of the valleys and depressions varies in the different parts of the valley landscape, the trend of the zones with glaciofluvial deposits also varies.

The subglacial meltwater drainage shows that the ice sheet at least at the base was mainly at the pressure melting point. Furthermore, the coarse-grained stratified drift suggests that surface meltwater penetrated the ice sheet and was drained along its base (cf. Chapter 5.1.4). Such a penetration is indicated by the occurrence of varved clay and Ringberg's (1971) investigations of proximal varves in the southern part of the valley landscape (cf. Chapter 7.6.2). Consequently, the ice sheet was mainly at the pressure melting point in a marginal zone during the recession in the valley landscape.

8.5.2 The highest shoreline and water-level changes

The great number of beach deposits below 50-60 m a.s.l. show that the highest shoreline is located 50-60 m a.s.l. (Blomberg 1900; G. De Geer 1889b; Hellberg 1971; Dahlberg 1976; Malmberg 1976; L. Nilsson 1976; Svensson 1976). This is also indicated by the delta deposits at Vånga and Olofström and the ice-marginal delta deposits in the valley between Näsrum and Olofström, the top surfaces of which reach 50-60 m a.s.l. (Hellberg 1971). From the above and from the fact that I have not found any beach deposits above 50-60 m a.s.l. in the area between Oppmanna and Immeln Lake, I conclude that Munthe's (1940) and E. Nilsson's (1942, 1953, 1968) opinions on the highest shoreline are incorrect.

Since the top surfaces of the ice-marginal delta deposits in the Näsrum - Olofström valley and the highest shoreline are located at 50-60 m a.s.l., it follows that a regression prevailed during the deglaciation of the valley landscape.

9 Regional synthesis

9.1 Glacial striae

The glacial striae in the Kristianstad area reflect the ice movement directions that prevailed in a marginal zone of the ice sheet. This can be deduced because the ice sheet was active during the recession except for a zone with stagnant ice that remained in areas where deglaciation was subaerial (Chapter 9.6). That the ice sheet was active is also indicated by the diverging glacial striae around and south of Njura (Chapter 8.5.1, Fig. 91). Consequently, the glacial striae show that northeasterly to east-northeasterly ice movement directions prevailed in the southern part of the Kristianstad area during the recession of the ice sheet (Plate 1). In the central and northern parts, northerly to north-easterly directions are indicated.

In certain parts of Sweden and Finland, it was possible to determine the trend of the ice margin by varve chronological investigations or ice-marginal deposits. The ice margin here was sometimes lobe-shaped and estuaries also occurred (Sauramo 1923; G. Lundqvist 1955; Fromm 1972; Magnusson 1972, 1975; Punkari 1982). Where the ice margin was lobe-shaped, the majority of the glacial striae are diverging and where estuaries existed, they are converging. These striae can only indicate ice movements close to the margin of the ice sheet. It therefore seems plausible that striae in general reflect ice movements in a marginal zone of the ice sheet. This is supported by Strömberg's (1971) investigations in the area around the Åland Sea.

Thus, it is incorrect to deduce the direction of movement of the ice sheet far inside the ice margin by constructing flow lines on

the basis of glacial striae in the way Torell (1859, 1865), Holmström (1865, 1867, 1904) and G. De Geer (1884) did in the Kristianstad area (Chapters 3.1-3.3 and 3.5). However, it is possible that some striae formed far inside the ice margin could be preserved. Therefore, the older north-northwesterly to northerly striae, northwest of Kristianstad and on the southeastern part of the Linderödsåsen horst may suggest the direction of an ice movement that prevailed before the deglaciation. Holmström (1904) deduced this and named it the High Baltic Ice Stream (Chapter 3.5).

Lundbohm (1888) concluded that the easterly striae on the hill of ryssberget east-northeast of Kristianstad indicated an ice movement from the east (Chapter 3.4). This ice movement direction was considered to have prevailed before the deglaciation and Holmström (1904) named it the Old Baltic Ice Stream (Chapter 3.5). I do not agree with this conclusion because the site with the striae is located in an east-west trending depression, which might have caused a local deflection of the ice movement during the recession of the ice sheet.

9.2 Till

The genesis of the till was investigated at six exposures (Chapter 5.2.3: site 12, Chapter 5.3.3: site 13, Chapter 6.1.2: sites 127 and 128 and Chapter 7.2.2: sites 129 and 130) and in the area around Brösarp on the Linderödsåsen horst (Chapters 5.7.6 and

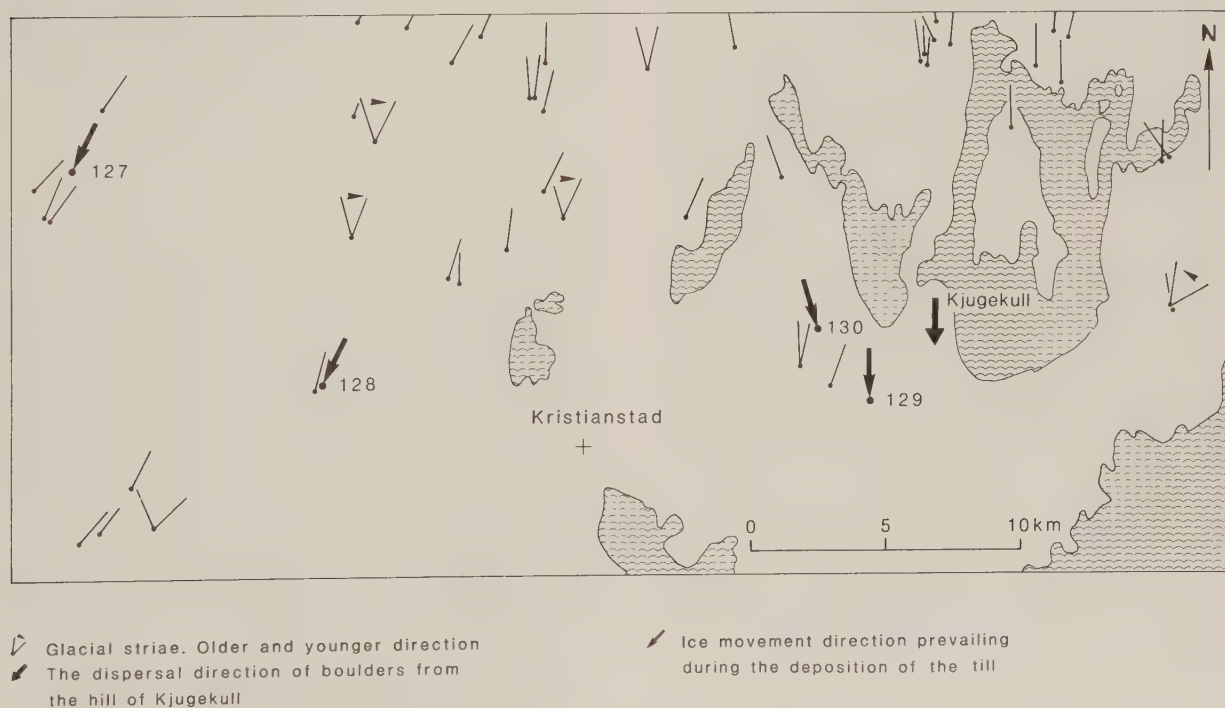


Fig. 101. Glacial striae, the direction of dispersal of boulders from the hill of Kjugekull and the ice movement directions which prevailed when the tills at sites 127-130 were deposited.

5.10.4).

Most of the investigated till was deposited at the base of an active ice sheet. At its base at least, the ice sheet was mainly at the pressure melting point during deposition of the till. The till is made up partly of far-travelled and englacially transported clasts and partly of clasts deriving from the local bedrock which were transported close to the base of the ice sheet. The action of subglacial meltwater, which resulted in deposition of stratified drift beneath the ice sheet contributed to the formation of the till. During the accumulation, this material and the melted-out drift were deformed to a varying degree by the active ice sheet. It is likely that deposition of till took place in a marginal zone of the ice sheet, since glaciotectionic deformation mainly is to be expected here (Boulton, Dent & Morris 1974; Boulton 1975).

At four sites it was possible to determine the direction of the ice movement at the time the till was deposited (Fig. 101). The direction was between north-northwesterly and north-northeasterly. The dispersal of boulders from the hill of Kjugeskull (Chapter 7.2.3, Fig. 80) indicates an ice movement from the north (Fig. 101). These directions are in good agreement with the local ice movement directions as indicated by glacial striae.

Lithological investigations of the till that covers the main part of the Linderödsåsen horst showed that the till is predominated by crystalline rock fragments, which to a large extent are derived from the local bedrock (Chapter 5.10.4, Appendix 2). On the central part of the horst, the till also contains Cambrian sandstone and Palaeozoic limestone from the area around the islands of Öland and Gotland (Chapter 5.10, Fig. 59). These rock fragments were deposited simultaneously with the gneiss fragments eroded on the horst (Fig. 63).

Indicators from the area around Öland and Gotland were also found in the clay till occurring along the eastern slope of the Linderödsåsen horst (Chapter 5.10.5). Apart from locally eroded rock fragments, the till contains the same indicators as the till on the horst.

Also, the till on the southern part of the plain around Kristianstad contains Cambrian sandstone and Palaeozoic limestone (Fig. 75).

The implications of the lithological composition of the till on the ice movement directions is discussed in Chapter 9.7.

9.3 Glaciofluvial deposits

The meltwater that transported the sediments which make up the glaciofluvial deposits flowed at the base of the ice sheet. It consisted mainly of surface meltwater which penetrated the ice sheet (e.g. Chapter 7.6.2). The subglacial meltwater was concentrated by valleys and depressions where the glaciofluvial sediments accumulated. Less than 10 m deep depressions also controlled the meltwater drainage.

In areas where the deglaciation was sub-aerial, the glaciofluvial sediments are made up mainly of stony gravelly sand that forms ridges and extended deposits. The latter consist of mounds, plateaus, hummocks and thin deposits with gently undulating surfaces. The sediments accumulated in stagnant ice which remained in front of the active ice during the recession of the ice sheet due to a cover of till or stratified drift (Chapter 5.12.3). The deposition took place gradually

in the direction of the recession of the ice sheet (e.g. Chapter 5.6.4). The stratified drift that forms ridges accumulated in non-disintegrated glacier ice and directly on till or bedrock. In some parts of the investigated area it was possible to show that the ridge-forming sediments accumulated where the meltwater tunnel was transformed into an open channel (Chapters 5.1.4 and 5.6.4). This mode of deposition differs from Bergdahl's (1953) opinion in that it stresses that most of the stratified drift did not accumulate in the tunnel itself (cf. Chapter 3.13). The sediments making up the extended, hummocky deposits accumulated in disintegrating glacier ice. Deposition took place directly on till or bedrock as well as in and on glacier ice (e.g. Chapter 5.6.4, Figs. 25 and 26).

In areas where the deglaciation was sub-aqueous, the glaciofluvial deposits are mainly made up of gravelly sand and sand but stony gravelly sand is also present. The gravelly sand forms mounds, plateaus and deposits with horizontal surfaces and gently sloping sides. The stony gravelly sand makes up ridges and also occurs along with the gravelly sand and sand in the above-mentioned morphological elements.

The sediments accumulated at the ice margin by gradual stages during the recession of the ice sheet. This mode of deposition is similar to that proposed by G. De Geer (1897, 1940) and later by e.g. Helm (1971), Banerjee & McDonald (1975), Rust & Romanelli (1975) and Saundersson (1975). Where the meltwater tunnels ended, estuaries may have occurred and the sediments making up the ridges may have accumulated in the inner parts of these estuaries (Chapter 7.6.1).

9.4 Varved clay

The varve chronology established by Antevs (1915) and Ringberg (1979) shows that the ice sheet receded toward the north and had a roughly east-west trending margin in the central part of the Kristianstad area (Fig. 100). Ringberg's (1971) investigations of proximal varves indicate that the stratified drift accumulated mainly in the summer season (Chapter 3.20).

9.5 Beach deposits

Beach deposits and the upper level of wave-washed till show that the highest shoreline is located at 50-60 m a.s.l. in the central part of the investigated area (Chapters 7.5, 7.6.3, 8.4 and 8.5.2) and at 25-50 m a.s.l. in the southern part (Chapters 5: introduction section and 5.12.5). The highest shoreline indicates the highest level of the Baltic Ice Lake. Thus, Munthe's (1940) and E. Nilsson's (1942, 1953, 1968) opinion that the Baltic Ice Lake reached about 100 m a.s.l. in the central and northern parts of the investigated area must be rejected (cf. Chapters 3.8, 3.11, 3.14 and 3.17).

A regression most likely prevailed during the deglaciation of the Kristianstad area (Chapters 7.6.3 and 8.5.2).

9.6 The properties of the ice sheet

During the recession in the Kristianstad area, the ice sheet had a sloping surface and was

active, except for a zone with stagnant ice that remained in areas where the deglaciation was subaerial. The following facts point to an active ice sheet:

- 1) The ice sheet receded by gradual stages and had a sloping surface (e.g. Chapters 5.6.4, 7.6.2 and 8.5.1).
- 2) The ice sheet readvanced during the recession as the upper till along the eastern border of the Linderödsåsen horst (Chapter 5.11.1: Ice-marginal line M) and the deformed stratified drift at site 131 (Chapter 7.3.1) indicate.
- 3) The glacial striae in the area around and south of Njura (Chapter 9.1).
- 4) Glaciotectonic deformation of till which probably took place in a marginal zone of the ice sheet (Chapter 9.2).

During the recession, most of the ice sheet ought to have been at the pressure melting point at least in a marginal zone. Where the deglaciation was subaqueous, this is indicated by varved clay and glaciofluvial deposits (Chapters 5.6.6, 7.6.2 and 8.5.1) and where the deglaciation was subaerial it is suggested by the coarse-grained glaciofluvial deposits (e.g. Chapter 5.1.4).

9.7 Ice movement directions

As my investigation of the till was not extensive enough to present a well-founded theory on the ice movement directions during the glaciation, I will only look at my findings in the light of previous investigations.

I discuss Holmström's (1904) opinion on the directions of the ice movement, i.e. the ice streams, in the eastern part of Skåne (Chapter 3.5). I have chosen to discuss his model for two reasons. Firstly, because it is the most complete model presented to date which is based on data from the area I have investigated. Secondly, because it was widely accepted until the foundations of the model were discussed by Lagerlund (1977).

The existence of an Old Baltic Ice Stream was in the Kristianstad area deduced from easterly glacial striae on Ryssberget (Chapter 3.4) as well as from the occurrence of indicators from the area around Gotland and Öland (Fig. 58) found in the till on the central part of the Linderödsåsen horst (Chapter 3.3) and in beach gravel at Ivösjön Lake (Chapter 3.4). However, these indications are open to question. The glacial striae could have been formed during the recession of the ice sheet (Chapter 9.1). The indicators from the Baltic depression found in the till on the Linderödsåsen horst are not redeposited but accumulated simultaneously with the rest of the material that makes up the till (Chapter 9.2). The stratigraphical position of the Baltic indicators at Ivösjön Lake is unknown.

The Meridian Ice Stream and the High Baltic Ice Stream were mainly indicated by glacial striae (Chapter 3.5) and the lithological composition of the till on the central part of the Linderödsåsen horst (Chapter 3.3). However, most of the glacial striae reflect the direction of the ice movement that prevailed in a marginal zone of the ice sheet, although they may also suggest an older ice movement from around the north (Chapter 9.2). The conclusion that the lithological composition of the till on the central part of the Linderödsåsen horst indicates a north-north-

easterly ice movement is questionable for two reasons. Firstly, the mica quartzite in the till may have been derived from outcrops on the horst instead of from the outcrop in the northeastern part of Skåne (Chapter 5.10.4). Secondly, the Cretaceous rock fragments need not necessarily have been eroded on the plain around Kristianstad, since Cretaceous rocks also occur in Hanöbukten Bay (Fig. 58).

The existence of the Low Baltic Ice Stream in the southeastern part of Skåne was based on the till that occurs here and contains indicators from the area around Öland and Gotland (Chapters 3.3 and 3.5, Plate 2C and E). The till was considered to indicate a radical change in the direction of the ice movement because the till deposited by the Meridian Ice Stream and the High Baltic Ice Stream did not contain non-redeposited indicators from the above-mentioned area (cf. Chapter 3.10). As the till is sometimes overlaid by stratified drift, a considerable advance during the shrinkage of the ice sheet was deduced. I find these conclusions uncertain for two reasons. Firstly, the till and the underlying stratified drift may have accumulated in connection with several small readvances during the recession of the ice sheet. Secondly, the lithological composition of the tills in the southern part of the Kristianstad area (Chapter 9.2) does not support Holmström's idea. G. De Geer (1889a) and Holmström (1904) considered that the till along the eastern border of the Linderödsåsen horst (Chapters 5.10.5 and 5.11.1: Ice-marginal line M) accumulated when the Low Baltic Ice Stream advanced. The till further to the west (Chapter 5.10.4) was to have been deposited when the Meridian Ice Stream and the High Baltic Ice Stream existed. However, both of these tills contain Baltic indicators. Thus, it need not necessarily be so that the tills represent two significantly different ice movement directions. The till along the border of the horst may have accumulated when the ice sheet made a minor advance.

9.8 The recession of the ice sheet

The ice sheet receded in a northeasterly to east-northeasterly direction in the southern part of the Kristianstad area and in a northerly to northeasterly direction in the central and northern parts of this area (Fig. 102). The recession lines indicate the trend of the boundary between stagnant and active glacier ice where the deglaciation was subaerial and the trend of the ice margin where it was subaqueous. They are based on the following indications (Figs. 66 and 100):

- 1) The direction of slope of the ice surface as indicated by zones with glaciofluvial deposits located in areas with irregular morphology and low relief.
- 2) Glacial striae.
- 3) The damming of glacial lakes on the southeastern part of the Linderödsåsen horst.
- 4) Varve chronological investigations by Ringberg (1979) in the area around Kristianstad.

The varve chronological investigations by Stay (1979) and Duphorn et al. (1981) in Hanöbukten Bay (Chapter 3.22) suggest that the ice margin was lobe-shaped here.

It was not possible to judge how far

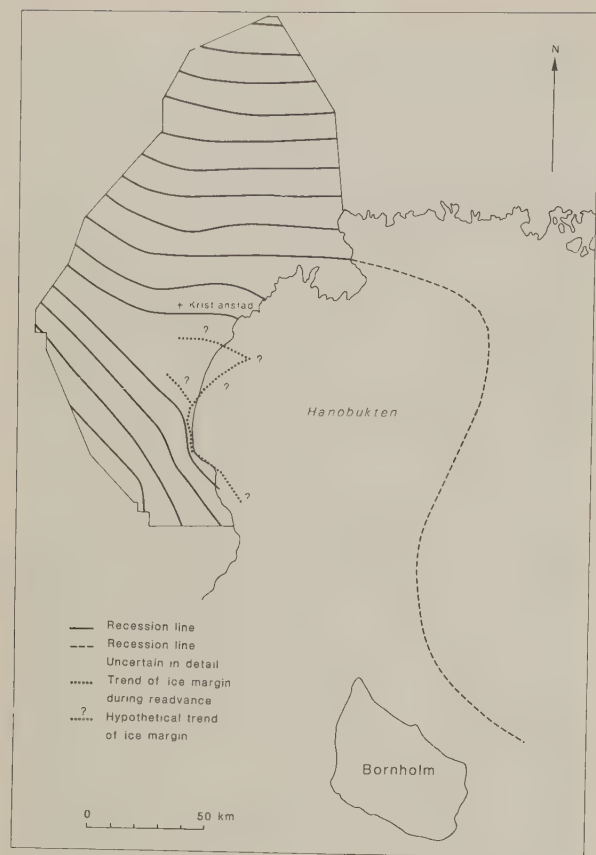


Fig. 102. The recession of the ice sheet in the Kristianstad area and in Hanöbukten Bay.

the ice sheet receded in Hanöbukten Bay before it readvanced and deposited the upper till east of Brösarp (Chapter 5.11.1: Ice-marginal line M). However, the trend of the recession lines on the horst is similar to the trend of the ice margin during the deposition of the upper till. This, and the lithological composition of the upper till and of the till further west of the horst (the lower till), suggest the possibility of a minor readvance. The trend of the ice margin on the plain around Kristianstad during the readvance is uncertain. Two hypothetical trends are suggested in Fig. 102. The eastern line is similar to Mörner's (1969) line 3 in the area northeast of Brösarp (Chapter 3.18, Plate 2). The trend of the ice margin southeast of Brösarp in Hanöbukten Bay is also uncertain (Chapter 5.11.3, Fig. 65E).

The percentage of Palaeozoic limestone in relation to the percentage of Cambrian sandstone is higher in the upper till than in the lower till (Chapter 5.10.5: Table 3). This suggests that more easterly transported drift accumulated during the readvance of the ice sheet which might be explained by the simultaneous growth of a marginal dome south of the investigated area (cf. Chapter 3.21: Lagerlund 1980, Plate 2U).

Previous investigations concerning the recession of the ice sheet in the eastern part of Skåne and in Hanöbukten Bay are discussed below.

G. De Geer's (1884, 1896) and Holmström's (1904) opinions on the existence of an ice lobe in Hanöbukten Bay and in the southeastern part of Skåne (Holmström 1904: the Low

Baltic Ice Stream) have been discussed in Chapter 9.7.

Antev's (1915) recession lines were based on a large number of varve series that were easy to time correlate (Chapter 3.6, Plate 2F). This, as well as the fact that Antev's diagrams were checked by Ringberg (1979) indicate that his recession lines are correct.

G. De Geer's (1917) opinion on the recession of the ice sheet in Skåne and Hanöbukten Bay was based on a time correlation between a sequence of varved clay at Rörum and the Gothenburg moraine (Chapter 3.7, Plate 2G). He did not present any varve diagrams. However, E. Nilsson (1968) time correlated a varve series at Rörum with varve series from the area around Kristianstad (Chapter 3.17, Plate 2Q). In my opinion, Nilsson's correlation is not supported by his varve diagrams (Fig. 5). This and Hansen's (1933) conclusion that the varves at Rörum are not annual (Chapter 3.9) invalidate De Geer's correlation.

Munthe (1940) did not state on what information he based his recession lines in the area I investigated (Chapter 3.8, Plate 2H).

E. Nilsson's (1942) recession lines (Chapter 3.11, Plate 2K) were based on shoreline observations that are incorrect (Chapter 9.5).

Wennberg's (1949) recession line 1 (Chapter 3.12, Plate 2L) was based on the single assumption that the ice surface sloped very gently. It is contradicted by the glaciofluvial deposits and the glacial striae on the Linderödsåsen horst (Chapter 5.12.1, Fig. 66). Recession line 2 is incorrect because the ridges southeast and northeast of Listerlandet are most likely not terminal moraines but drumlin-shaped hills (Chapter 7.2.1, Fig. 74C). Also Ringberg (1971) rejected Wennberg's theory that indications in Blekinge showed the existence of an ice lobe in Hanöbukten Bay (Chapter 3.20). This conclusion is supported by Hellberg's (1971) investigations of the recession of the ice sheet on Listerlandet (Chapter 3.19).

My investigations on the Linderödsåsen horst (Chapter 5.12, Fig. 66) support Bergdahl's (1953) opinion on the recession of the ice sheet here.

E. Nilsson's (1953) evidence in support of recession line 1 (Chapter 3.14, Plate 2N) is weak. Firstly, he assumed that the depressions in the area between Sjöbo and Rörum are erosion channels formed by meltwater from the glacier-dammed lake Rörumissjön. However, since the meltwater which flowed beneath the active and non-disintegrated part of the ice sheet was controlled by the southern depression, as the zone with glaciofluvial deposits here indicates (Chapter 5.8.1, Fig. 53: subarea 8E), this depression existed before the deglaciation. Secondly, the delta at Sjöbo need not necessarily have been formed when the glacier-dammed lake Rörumissjön was in existence. The sediments making up the delta may just as well have accumulated before the area around Rörum was deglaciated.

Nilsson's recession lines 2-4 were based on shoreline observations that are incorrect (Chapter 9.5).

E.H. De Geer's (1954, 1957) opinion on the recession of the ice sheet was mainly based on the works of G. De Geer (1917) and Nilsson (1953), which have been discussed above. Furthermore, the varved clay at Rörum is not overlaid by till (Chapter 5.9, Fig. 55), which means that the readvance indicated by line 3 must be rejected.

E.H. De Geer (1962) based the southern part of recession line 1 (Plate 2P) on a

time correlation between varve series at Kabusa and Rörum (Chapter 3.16). The varve series were presented by E. Nilsson (1968). The correlation is discussed below. Except for Antev's (1915) varve chronological investigations, lines 2-8 were mainly based on information gathered from outside the area I investigated.

E. Nilsson (1968) based the southern part of line 1 (Plate 2Q) on a time correlation between varve series from Kabusa and Rörum. In my opinion his varve diagrams (Fig. 5) do not support this correlation or the correlation with the varve series around Kristianstad. Since it is difficult to time correlate Nilsson's other varve series from southern Sweden and some of the lines are based on incorrect shoreline observations (cf. Chapter 9.5), one may conclude that his recession lines are not accurate.

Mörner's 1969 line 1 (Chapter 3.18, Plate 2Q) is dubious for two reasons. Firstly, it is uncertain whether the lithological boundary in the till west of Simrishamn indicates the maximum extent of an ice lobe (the Low Baltic Ice Stream) because the local bedrock may also have had an influence on the lithological composition of the till here (cf. Chapter 5.10.4, Fig. 63). Secondly, the correlation between this lithological boundary and the zone with ridges described by Bergdahl (1953) is not supported by the recession lines indi-

cated by the glaciofluvial deposits west and south of S:t Olof (Fig. 66). Northeast of Brösarp, line 3 indicates a possible trend of the ice margin (Fig. 102). However, the basis for this line is doubtful, since the shoals southeast of Åhus most likely not are ice-marginal features (Chapter 7.2.1).

My investigations support most of Hellberg's (1971) recession lines in the area east-northeast of Kristianstad (Chapter 3.19, Plate 2S).

Ringberg's (1971, 1979) recession lines in Blekinge and Skåne (Chapter 3.20, Plate 2T) must be considered correct because they are based on a large number of varve series in a restricted area and because characteristic varve sequences made the time correlation easy.

Lagerlund's (1980) opinion that a marginal dome existed south of the area I have investigated during the shrinkage of the ice sheet (Chapter 3.21, Plate 2U) may explain the difference in lithological composition between the upper till and the lower till on the Linderödsåsen horst.

The varve chronological investigations by Stay (1979) and Duphorn et al. (1981) suggest that an ice lobe existed in Hanöbukten Bay during the recession of the ice sheet. However, more varve data are needed in order to establish the recession of the ice sheet with certainty here.

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Appendix 1

Grain-size analyses.

Sample	Site	Gravel		Sand			Silt			Clay	Comments
		coarse	fine	coarse	medium	fine	coarse	medium	fine		
		20 mm	6	2	0.6	0.2	0.06	0.02	0.006	0.002	
		%	%	%	%	%	%	%	%	%	
G 1	3	21	15	16	19	17	8	2	2	0	sandy till
G 2	8	12	15	14	22	23	8	2	2	2	sandy till
G 3	12	28	12	13	17	16	7	4	2	1	sandy till
G 4	106	-	-	2	7	22	10	16	11	32	clay till
G 5	26	8	8	13	22	21	6	6	6	10	clayey till
G 6	26	4	6	13	23	26	12	6	6	4	sandy till
G 7	26	4	9	12	25	22	8	6	6	8	clayey till
G 8	27	6	12	19	33	18	8	2	2	0	sandy till
G 9	27	3	5	14	30	24	10	5	3	6	clayey till
G 10	27	6	6	12	30	22	10	4	4	6	clayey till
G 11	66	7	6	16	33	24	10	2	2	0	sandy till
G 12	66	1	4	8	24	22	10	8	6	17	clay till
G 13	66	4	5	10	26	20	7	6	6	16	clay till
G 14	70	3	4	9	30	26	11	5	4	8	clayey till
G 15	70	5	6	11	26	23	7	7	5	10	clayey till
G 16	70	1	4	14	28	24	8	7	4	10	clayey till
G 17	81	2	3	8	32	26	7	6	4	12	clayey till
G 18	81	4	3	8	32	26	10	6	4	7	clayey till
G 19	81	3	3	10	26	29	11	5	5	8	clayey till
G 20	87	2	4	10	30	23	10	6	3	12	clayey till
G 21	87	3	3	9	29	25	9	6	4	12	clayey till
G 22	87	1	3	9	32	24	10	5	5	11	clayey till
G 23	120	6	6	13	27	21	10	5	2	10	clayey till
G 24	120	8	4	12	24	20	6	4	4	18	clay till
G 25	120	24	14	14	19	12	5	4	2	6	clayey till
G 26	120	26	18	14	16	10	6	2	3	5	clayey till
G 27	121	2	3	10	28	21	6	7	6	17	clay till
G 28	121	5	9	12	22	18	5	7	6	16	clay till
G 29	121	6	10	12	21	17	7	7	5	15	clay till
G 30	122	1	2	4	11	15	10	12	15	30	clay till
G 31	122	3	2	9	23	21	10	10	10	12	clayey till
G 32	122	3	5	12	24	22	8	6	7	13	clayey till

Appendix 2

Lithological analyses. Cam. sast. = Cambrian sandstone. Pal. lst. = Palaeozoic limestone. Cret. l. sast., sa. lst. and lst. = Cretaceous limy sandstone, sandy limestone and limestone. Cret. flint = Cretaceous flint. Others = Other kinds of rocks.

Sample	Site	Size frac-tion	Number of grains	Crys-talline rocks	Red mica quart-zite	Cam. sast. Total red	Shale and alum shale	Pal. lst. Total red	Cret. l. sast., sa. lst. and lst.	Cret. flint	Others	Com-ments
				%	%	%	%	%	%	%	%	
1	1	3-4	634	99.8	—	—	—	—	0.2	—	—	
1	1	4-11	498	100.0	—	—	—	—	—	—	—	
2	5	3-4	536	98.1	—	0.2/-	—	0.2/0.2	1.3	0.2	—	
3	7	3-4	540	98.4	—	0.4/-	—	—	0.9	0.4	—	
4	8	3-4	621	98.9	—	0.2/-	—	—	0.8	—	0.2	
4	8	4-11	522	98.7	—	—	—	—	0.4	0.6	0.4	
5	11	3-4	780	100.0	—	—	—	—	—	—	—	
5	11	4-11	443	100.0	—	—	—	—	—	—	—	
6	12	3-4	701	99.6	—	0.1/-	—	—	—	—	0.3	
6	12	4-11	434	99.1	—	0.2/-	—	—	0.2	0.2	0.2	
7	13	3-4	653	96.9	—	1.4/-	—	—	0.6	0.9	0.2	
7	13	4-11	532	97.3	—	0.2/-	—	—	0.8	1.1	0.6	
8	16	3-4	552	98.3	—	0.4/-	—	—	0.2	0.9	—	
8	16	4-11	405	97.5	—	0.7/-	—	—	0.2	0.7	0.5	
9	17	3-4	628	98.4	—	0.5/-	—	—	0.3	0.3	0.5	
10	20	3-4	596	97.2	—	1.2/-	—	—	1.2	0.2	0.3	
11	22	3-4	688	98.1	—	0.6/-	—	—	0.3	0.4	0.6	
12	23	3-4	656	95.5	—	1.4/-	—	—	0.9	1.6	0.5	
13	25	3-4	599	85.8	—	4.0/-	—	4.0/1.2	3.8	0.8	1.5	
14	26	3-4	631	97.5	—	0.8/-	—	—	0.5	0.2	1.0	
15	26	3-4	681	92.6	—	1.1/-	—	1.5/0.4	3.1	0.6	1.1	
15	26	4-11	404	92.1	—	1.5/-	—	1.0/0.2	3.7	0.7	1.0	
16	26	3-4	554	97.6	—	0.7/-	—	0.2/-	0.4	—	1.1	
17	27	3-4	622	95.9	—	1.6/-	—	—	0.5	0.6	1.4	
18	27	3-4	552	93.8	—	2.2/0.2	—	0.7/-	2.9	0.2	0.2	
19	27	3-4	533	90.1	0.2	1.1/-	—	0.9/-	3.2	0.9	4.0	
19	27	4-11	433	89.9	0.2	1.8/-	—	0.2/-	6.9	0.7	0.2	
20	28	2-4	1045	76.5	—	3.1	—	4.6	15.9	—	—	1
21	31	2-4	653	75.1	—	2.9	0.2	8.0	13.8	—	—	1
22	31	2-4	551	88.0	—	1.6	—	3.1	7.3	—	—	1
23	43	3-4	719	74.1	—	7.5/0.6	2.4	9.2/0.6	4.9	1.0	1.0	
23	43	4-11	274	77.1	—	11.7/0.4	—	2.9/0.4	5.5	2.6	0.4	
24	44	3-4	666	73.4	—	11.2/0.2	2.4	8.4/0.9	3.2	0.6	0.9	
25	45	3-4	766	76.1	—	8.4/0.5	0.9	8.0/1.4	3.6	0.5	1.7	
25	45	4-11	1256	69.6	—	9.9/0.8	2.1	10.5/1.6	4.5	1.2	2.1	
26	—	3-4	715	74.4	—	10.6/0.3	1.7	7.0/0.8	3.5	0.8	2.0	
27	46	3-4	1086	77.7	—	7.5/0.6	1.4	6.7/0.9	4.0	0.6	2.2	
27	46	4-11	392	71.0	—	10.7/0.3	2.3	7.9/1.0	6.6	1.0	0.3	
28	47	3-4	725	74.7	—	6.2/0.4	2.5	5.0/1.1	9.1	1.2	1.2	
29	48	3-4	732	74.0	—	8.5/0.7	1.2	12.2/2.7	3.7	0.4	—	
30	49	3-4	511	69.9	—	9.2/1.0	2.5	12.5/2.5	3.5	0.4	2.0	
31	53	2-6	923	92	—	—	0.2	0.8	7	—	—	2
32	56	3-4	763	72.9	—	5.4/0.5	2.4	9.7/1.9	8.2	0.5	0.9	
32	56	4-11	413	71.6	—	5.6/-	2.2	10.4/0.7	8.2	1.5	0.5	
33	64	3-4	542	80.8	—	4.6/0.2	—	6.8/1.7	4.6	0.6	2.6	
34	65	3-4	585	80.0	—	4.5/0.3	—	1.9/0.2	10.2	2.2	1.0	
35	66	3-4	606	93.6	—	3.0/0.2	—	—	1.5	0.2	1.8	
36	66	3-4	606	79.1	—	3.8/-	0.5	7.3/0.7	5.8	1.5	2.0	
36	66	4-11	406	76.6	—	2.5/-	0.5	8.4/1.5	10.3	0.7	1.0	
37	66	3-4	537	78.1	—	2.3/-	—	5.2/0.4	9.5	1.3	3.7	
38	67	3-4	669	81.6	—	5.1/0.5	—	2.4/0.4	7.2	0.5	3.3	
39	68	3-4	464	87.7	—	3.9/0.2	—	1.9/0.2	4.3	—	2.2	
39	68	4-11	389	88.9	0.3	2.1/0.3	0.8	3.3/0.8	3.6	0.8	0.3	
40	69	3-4	525	81.6	—	4.2/0.6	0.2	3.6/0.8	6.7	1.3	2.3	
40	69	4-11	439	80.4	—	3.5/0.5	0.2	6.8/1.6	6.8	1.6	0.7	
41	70	3-4	781	97.7	—	0.5/-	—	—	0.5	0.6	0.6	
42	70	3-4	603	78.3	—	3.4/0.5	0.3	5.5/1.8	10.8	0.5	1.2	
42	70	4-11	384	74.2	—	4.2/0.8	0	6.0/2.1	13.5	1.8	0.3	
43	70	3-4	577	95.0	—	1.2/-	0.2	0.7/-	1.4	0.2	1.3	
44	70	3-4	673	83.2	—	4.3/0.7	0.3	4.3/0.6	5.8	0.6	1.4	
45	72	3-4	432	81.4	—	4.1/0.5	—	3.7/1.4	7.2	0.9	2.5	
46	—	3-4	471	76.9	—	5.9/0.4	—	1.9/-	12.1	1.5	1.7	
47	—	3-4	793	80.8	—	3.9/0.4	—	4.3/0.6	9.7	0.2	1.0	
48	73	3-4	473	79.3	—	4.8/0.4	—	4.4/1.7	7.4	0.8	3.2	
49	—	3-4	759	79.6	—	4.0/0.3	0.1	4.1/1.2	10.3	0.9	1.0	
49	—	4-11	320	80.7	—	5.0/0.3	—	4.7/0.9	8.4	0.6	0.6	
50	75	3-4	522	84.6	—	4.7/-	0.2	2.9/0.8	5.2	0.6	1.7	
51	—	3-4	565	75.4	—	4.6/-	—	3.0/0.4	11.3	1.2	4.2	
52	77	3-4	642	86.6	—	3.1/0.3	—	4.4/0.2	3.9	0.6	1.4	
53	80	3-4	432	66.7	—	11.6/0.7	—	0.2/-	14.6/1.9	3.9	1.4	
54	81	3-4	542	92.2	—	4.8/1.1	0.4	—	0.9	0.4	1.3	
55	81	3-4	509	88.7	—	4.0/0.4	0.6	2.2/0.4	2.0	0.6	2.2	
56	81	3-4	546	87.9	—	6.5/-	0.4	0.5/0.2	2.2	1.1	1.2	
57	81	3-4	686	72.1	0.1	5.9/0.1	—	7.1/0.4	10.3	0.9	3.4	

Sample	Site	Size frac- tion	Number of grains	Crys- talline rocks	Red mica quartz- zite	Cam. sast. Total red	Shale and alum shale	Pal. 1st. Total red	Cret. 1.sast., sa. 1st. and 1st.	Cret. flint	Others	Com- ments
				%	%	%	%	%	%	%	%	
58	81	3-4	645	77.2	—	4.0/-	0.9	7.8/1.6	8.5	0.6	1.0	
58	81	4-11	412	81.1	—	4.1/0.2	—	6.8/1.0	6.1	1.0	1.0	
59	83	3-4	498	77.0	—	3.2/0.8	—	4.6/1.4	11.8	1.2	2.0	
60	84	3-4	604	34.2	—	9.1/3.0	10.3	45.0/1.8	0.5	0.3	0.5	
60	84	4-11	1177	33.2	—	10.3/3.9	9.1	44.8/4.1	0.6	0.3	1.7	
61	84	3-4	830	37.0	—	11.2/6.9	11.8	31.3/1.0	6.6	1.1	1.1	
61	84	4-11	1345	29.3	—	18.8/13.8	7.3	42.2/1.3	1.1	0.1	1.2	
62	85	3-4	729	72.4	—	5.3/1.6	—	17.2/1.2	3.4	0.8	1.0	
62	85	4-11	2017	65.6	—	9.8/3.3	0.1	20.5/0.8	2.0	1.0	1.0	
63	85	3-4	686	84.0	—	3.5/1.2	0.1	5.7/1.3	3.8	0.9	2.0	
64	—	3-4	603	90.2	—	5.2/1.8	1.7	—	0.7	1.0	1.2	
65	87	3-4	607	90.3	—	5.6/0.5	0.8	0.2/-	0.7	1.5	1.0	
66	87	3-4	554	90.7	—	4.9/0.2	1.1	—	0.5	1.3	1.4	
67	87	3-4	619	90.1	—	6.0/0.8	—	—	1.1	1.0	1.6	
68	87	3-4	558	90.3	—	3.4/-	0.4	0.4/-	0.9	1.3	3.4	
69	—	3-4	413	93.9	—	3.6/-	1.0	—	0.2	—	1.2	
70	—	3-4	540	87.6	—	8.7/1.1	0.4	—	0.6	1.3	1.5	
71	—	3-4	551	89.4	—	7.1/0.2	0.2	—	0.5	0.2	2.7	
72	—	3-4	650	90.0	—	0.5/-	8.3	—	0.2	0.2	0.9	
73	97	3-4	423	74.4	—	10.6/3.3	5.9	1.9/-	3.3	—	3.8	
74	100	3-4	721	78.8	—	5.9/0.6	0.3	6.7/0.3	6.5	0.8	1.0	
75	101	3-4	501	45.9	—	6.6/1.2	10.2	29.5/1.2	4.4	—	3.4	
75	101	4-11	170	41.7	—	9.5/0.6	3.5	35.3/3.5	5.9	0.6	3.5	
76	105	3-4	115	53.0	—	8.7/1.7	11.3	20.9/-	4.3	—	1.7	
77	—	3-4	522	73.1	—	15.3/3.2	8.2	—	0.6	—	2.7	
78	106	3-4	395	44.1	—	9.9/4.3	18.7	25.2/1.8	1.5	0.2	0.2	
78	106	4-11	104	28.8	—	12.5/6.7	15.4	34.6/2.9	0.1	—	7.7	
79	109	3-4	558	66.8	—	8.5/0.4	0.9	8.9/1.4	8.8	1.2	4.6	
80	—	3-4	845	72.9	—	7.5/0.2	1.9	8.4	7.4	0.9	0.8	
81	113	3-4	634	77.7	—	6.3/1.0	0.5	7.2/1.1	5.7	0.5	2.0	
82	—	3-4	521	44.2	—	6.6/1.2	11.5	31.9/1.2	3.3	0.2	2.3	
83	—	3-4	916	73.5	—	6.9/0.8	1.3	13.5/1.6	3.9	0.1	0.6	
84	115	3-4	245	36.7	—	6.1/2.8	16.3	40.0/1.1	0.8	—	—	
85	116	3-4	538	36.4	—	6.7/1.3	12.6	38.8/2.8	1.5	—	3.9	
85	116	4-11	270	31.1	—	8.2/2.2	7.4	44.1/2.2	6.3	0.7	2.2	
86	120	3-4	514	83.1	—	2.7/-	9.3	—	0.4	0.8	3.7	
87	120	3-4	792	85.9	0.3	3.5/0.4	8.5	—	0.1	0.8	1.0	
88	120	3-4	587	92.6	—	1.4/0.2	2.7	—	0.7	1.0	1.5	
89	120	3-4	625	99.5	—	0.2/-	0.3	—	—	—	—	
90	120	3-4	677	99.2	—	—	—	—	—	—	0.7	
91	—	3-4	530	88.6	—	5.6/0.9	0.8	—	0.8	2.3	1.9	
92	121	3-4	340	90.5	—	6.2/0.3	1.5	—	0.3	0.3	1.2	
93	121	3-4	526	91.2	—	4.4/0.4	0.8	—	0.2	1.1	2.3	
94	121	3-4	642	69.9	—	2.2/0.2	25.1	—	0.2	0.3	2.1	
95	121	3-4	786	74.4	—	2.0/-	21.9	—	0.3	—	1.5	
95	121	4-11	420	64.0	—	1.4/-	32.1	—	—	—	2.4	
96	122	3-4	511	84.5	—	9.8/0.6	2.0	—	0.6	0.4	2.7	
97	122	3-4	756	59.5	—	6.9/0.5	27.1	2.1/-	0.8	0.1	3.4	
98	122	3-4	561	69.3	—	5.7/0.4	6.2	8.9/0.9	6.2	0.7	2.8	
99	122	3-4	636	77.4	—	3.3/0.3	5.3	3.8/0.8	7.4	0.5	2.4	
99	122	4-11	553	73.6	—	5.0/-	8.7	4.2/0.9	6.9	0.9	0.7	

1) = Thuning 1980

2) = T. Nilsson 1961

Appendix 3

Location of sites and lithological analyses without site notation. The coordinates are given in the coordinate system named 'Rikets nät', which is indicated on the Topographical Map.

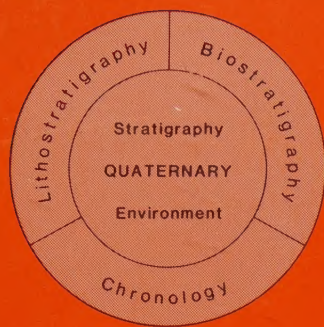
Sites

Site	X-coordinate	Y-coordinate	Topo-graphical Map	Site	X-coordinate	Y-coordinate	Topo-graphical Map
1	61 9955	13 7209	2D NV	65	61 8098	13 9155	2D NO / 2E NV
2	62 0043	13 7275	3D SV	66	61 8132	13 9122	2D NO / 2E NV
3	62 0103	13 7437	3D SV	67	61 8153	13 9210	2D NO / 2E NV
4	62 0215	13 7405	3D SV	68	61 8210	13 9155	2D NO / 2E NV
5	62 0272	13 7495	3D SV	69	61 8479	13 9180	2D NO / 2E NV
6	62 0286	13 7505	3D SO	70	61 8483	13 9242	2D NO / 2E NV
7	62 0385	13 7567	3D SO	71	61 8475	13 9280	2D NO / 2E NV
8	61 9223	13 8511	2D NO / 2E NV	72	61 8488	13 9288	2D NO / 2E NV
9	61 9405	13 8636	2D NO / 2E NV	73	61 8439	13 9370	2D NO / 2E NV
10	61 9317	13 8851	2D NO / 2E NV	74	61 8427	13 9380	2D NO / 2E NV
11	61 9520	13 8820	2D NO / 2E NV	75	61 8439	13 9454	2D NO / 2E NV
12	61 9592	13 8695	2D NO / 2E NV	76	61 8477	13 9483	2D NO / 2E NV
13	61 8900	13 7900	2D NO / 2E NV	77	61 8487	13 9510	2D NO / 2E NV
14	61 9013	13 8037	2D NO / 2E NV	78	61 8450	13 9540	2D NO / 2E NV
15	61 9067	13 8072	2D NO / 2E NV	79	61 8245	13 9508	2D NO / 2E NV
16	61 9105	13 8115	2D NO / 2E NV	80	61 8662	13 9485	2D NO / 2E NV
17	61 8532	13 7891	2D NO / 2E NV	81	61 8565	13 9647	2D NO / 2E NV
18	61 8585	13 7985	2D NO / 2E NV	82	61 8680	13 9630	2D NO / 2E NV
19	61 8607	13 8027	2D NO / 2E NV	83	61 8290	13 9598	2D NO / 2E NV
20	61 8720	13 8044	2D NO / 2E NV	84	61 8270	13 9680	2D NO / 2E NV
21	61 8275	13 8090	2D NO / 2E NV	85	61 8320	13 9680	2D NO / 2E NV
22	61 8080	13 8610	2D NO / 2E NV	86	61 8495	13 9797	2D NO / 2E NV
23	61 8280	13 8646	2D NO / 2E NV	87	61 7645	13 9552	2D NO / 2E NV
24	61 8442	13 8922	2D NO / 2E NV	88	61 7580	13 9635	2D NO / 2E NV
25	61 8533	13 8968	2D NO / 2E NV	89	61 7537	13 9611	2D NO / 2E NV
26	61 8760	13 8922	2D NO / 2E NV	90	61 7518	13 9634	2D NO / 2E NV
27	61 9074	13 8950	2D NO / 2E NV	91	61 7519	13 9682	2D NO / 2E NV
28	61 8855	13 9192	2D NO / 2E NV	92	61 7538	13 9675	2D NO / 2E NV
29	61 8885	13 9182	2D NO / 2E NV	93	61 7607	13 9680	2D NO / 2E NV
30	61 8887	13 9282	2D NO / 2E NV	94	61 7551	13 9713	2D NO / 2E NV
31	61 8992	13 9360	2D NO / 2E NV	95	61 7580	13 9722	2D NO / 2E NV
32	61 9012	13 9292	2D NO / 2E NV	96	61 7614	13 9756	2D NO / 2E NV
33	61 9075	13 9250	2D NO / 2E NV	97	61 7630	13 9840	2D NO / 2E NV
34	61 9116	13 9465	2D NO / 2E NV	98	61 7563	13 9887	2D NO / 2E NV
35	61 9161	13 9278	2D NO / 2E NV	99	61 7565	13 9897	2D NO / 2E NV
36	61 9190	13 9223	2D NO / 2E NV	100	61 7570	13 9911	2D NO / 2E NV
37	61 9342	13 9372	2D NO / 2E NV	101	61 7577	13 9925	2D NO / 2E NV
38	61 9355	13 9309	2D NO / 2E NV	102	61 7567	13 9925	2D NO / 2E NV
39	61 8005	13 8520	2D NO / 2E NV	103	61 7708	13 9900	2D NO / 2E NV
40	61 7832	13 8438	2D NO / 2E NV	104	61 7745	13 9900	2D NO / 2E NV
41	61 7853	13 8470	2D NO / 2E NV	105	61 7690	13 9855	2D NO / 2E NV
42	61 7797	13 8571	2D NO / 2E NV	106	61 7717	13 9837	2D NO / 2E NV
43	61 7660	13 8663	2D NO / 2E NV	107	61 7668	13 9690	2D NO / 2E NV
44	61 7673	13 8702	2D NO / 2E NV	108	61 7830	13 9535	2D NO / 2E NV
45	61 7682	13 8755	2D NO / 2E NV	109	61 7793	13 9615	2D NO / 2E NV
46	61 7853	13 9144	2D NO / 2E NV	110	61 7780	13 9675	2D NO / 2E NV
47	61 7855	13 9195	2D NO / 2E NV	111	61 7845	13 9690	2D NO / 2E NV
48	61 7940	13 9218	2D NO / 2E NV	112	61 7775	13 9737	2D NO / 2E NV
49	61 7952	13 9272	2D NO / 2E NV	113	61 7785	13 9810	2D NO / 2E NV
50	61 7980	13 9295	2D NO / 2E NV	114	61 7778	13 9814	2D NO / 2E NV
51	61 8000	13 9300	2D NO / 2E NV	115	61 7782	13 9838	2D NO / 2E NV
52	61 7975	13 9310	2D NO / 2E NV	116	61 7930	13 9877	2D NO / 2E NV
53	61 7882	13 9285	2D NO / 2E NV	120	61 7280	13 9693	1D NO / 2D SO
54	61 7871	13 9300	2D NO / 2E NV	121	61 7400	13 9790	1D NO / 2D SO
55	61 7842	13 9380	2D NO / 2E NV	122	61 7229	13 9942	1D NO / 2D SO
56	61 7867	13 9409	2D NO / 2E NV	123	62 0690	13 6970	3D SV
57	61 7900	13 9413	2D NO / 2E NV	124	61 1220	13 7260	3D SV
58	61 7915	13 9442	2D NO / 2E NV	125	62 1260	13 7270	3D SV
59	61 7865	13 9439	2D NO / 2E NV	126	62 1270	13 7180	3D SV
60	61 7812	13 9455	2D NO / 2E NV	127	62 2230	13 7880	3D SO
61	61 7775	13 9462	2D NO / 2E NV	128	62 1460	13 8720	3D SO
62	61 7732	13 9478	2D NO / 2E NV	129	62 1390	14 0770	3E SV
63	61 7735	13 9497	2D NO / 2E NV	130	61 1660	14 0580	3E SV
64	61 8030	13 9200	2D NO / 2E NV	131	62 0400	13 9080	3D SO

Site	X- coordinate	Y- coordinate	Topo- graphical Map
132	62 0555	13 9155	3D SO
133	62 2300	13 9325	3D SO
134	62 1885	13 9890	3D SO
135	62 1450	14 0235	3D SO
136	62 1580	14 0220	3E SV
137	62 1635	14 0415	3E SV
138	62 1680	14 0610	3E SV
139	62 1740	14 0595	3E SV
140	62 1920	14 0610	3E SV

Lithological analyses without site notation

Ana- lysis	X- coordinate	Y- coordinate	Topo- graphical Map
141	62 1060	14 1180	3E SV
L46	61 8386	13 9298	2D NO / 2E NV
L47	61 8368	13 9326	2D NO / 2E NV
L49	61 8420	13 9413	2D NO / 2E NV
L51	61 8355	13 9525	2D NO / 2E NV
L64	61 8061	13 9755	2D NO / 2E NV
L69	61 7450	13 9445	1D NO / 2D SO
L70	61 7508	13 9550	2D NO / 2E NV
L71	61 7493	13 9660	1D NO / 2D SO
L72	61 7613	13 9638	2D NO / 2E NV
L77	61 7733	13 9837	2D NO / 2E NV
L80	61 7815	13 9562	2D NO / 2E SV
L82	61 7743	13 9826	2D NO / 2E SV
L83	61 7672	13 9880	2D NO / 2E SV
L91	61 7494	13 9841	1D NO / 2D SO



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